

JACKSON MILLS & MINE FALLS DAMS

NASHUA, NEW HAMPSHIRE
HYDROELECTRIC FEASIBILITY

VOLUME 2

MINE FALLS DAM
RECONNAISSANCE REPORT

JANUARY 1980

NEW
HAMPSHIRE



**United States Army
Corps of Engineers**

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NASHUA

New England Division

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, NEW HAMPSHIRE

Reconnaissance Report
Hydroelectric Feasibility

VOLUME 2

MINE FALLS DAM

U. S. Army Corps of Engineers
New England Division
Waltham, MA

January 1980

EXECUTIVE SUMMARY

This study of hydroelectric development at Jackson Mills and Mine Falls Dams in Nashua, New Hampshire, is contained in two volumes: Volume 1 - Jackson Mills Dam and Volume 2 - Mine Falls Dam.

This report, Volume 2, has determined that hydroelectric development at Mine Falls Dam is feasible. The New England Division's role in the project was to give technical assistance to the City of Nashua. This reconnaissance report will form the basis for any additional actions taken by the city for hydropower development.

Hydroelectric power was generated at the Nashua Manufacturing Mills at the terminus of the Mine Falls canal system until the 1950's. Then, cheap oil became readily available and generation ceased. The region's current dependence on expensive imported oil, however, has aroused new interest in using New England's numerous rivers for hydroelectric power. Senator John A. Durkin of New Hampshire requested this study of hydroelectric feasibility to once again use Mine Falls to generate electricity. Specific authority is contained in a resolution, dated 6 December 1978, by the U.S. Senate Committee on Environment and Public Works.

Mine Falls Dam and associated canal were constructed between 1822 and 1825. A new gatehouse was built at the head of the canal in 1886, and extensive work was performed on the dam in the late 1920's.

At Mine Falls, a total of nine alternatives were considered for hydroelectric development. After assessing the impacts and engineering constraints, two plans were looked at in detail: (1) hydroelectric development at the damsite and (2) development along the canal about one mile downstream of the dam.

Development at the dam appears to be the most practical and feasible, as it would not disturb or be associated with the operation and maintenance of an old and delicate canal system.

The recommended plan for hydroelectric development at Mine Falls would locate a new powerhouse approximately 500 feet downstream from the dam along the southern bank of the river. An exposed penstock would extend from the south abutment of the dam along the river edge to the powerhouse.

The powerhouse would contain two horizontal shaft propeller turbines with runners of 1250-mm diameter, each capable of passing 330 cfs through an average head of 26.5 feet. The installed capacity is 1180 kw, and the average annual energy generation is estimated to be 5,540,000 kwh. The plant would be operated as an automatic run-of-river installation with no manned control room.

Environmental impacts of the recommended plan would be mainly those associated with the terrestrial environment and would be moderate in nature. Impacts on the aquatic ecosystem would be minor. The ground near the river, having surface bedrock and being frequently flooded, is an unlikely location for significant archaeological resources. Historical significance of the dam would require hydroelectric development at the site to complement the features of the existing structures.

Three possible marketing methods are discussed in this report: (1) sale to the grid system of the total power produced, (2) wheeling of power (paying a utility for the use of its transmission lines), (3) installing direct transmission lines, with provisions for standby power. The first plan, sale to the grid, would appear to be the best overall marketing method.

It was assumed for this analysis that the project would be funded and managed by the City of Nashua and that power would be sold directly to the Public Service Company of New Hampshire at the established rate of 4¢/Kwh. The project is expected to have a minimum life span of 40 years.

Total capital costs of the recommended plan are estimated at \$2.26 million. Annual operation and maintenance are estimated at \$40,200. Revenue from the sale of power is estimated to be \$221,600 annually. Using a 6-percent discount rate, the benefit-cost ratio of the recommended alternative is 1.16.

Another benefit to the city would be its ownership of an inflation-proof system: water is renewable and free. The hydroelectric power generated at the dam represents a savings in oil of 330,000 gallons each year.

Now that the Corps of Engineers' role has ended, the next step for the City of Nashua is procurement of a license from the Federal Energy Regulatory Commission (FERC).

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1.0 INTRODUCTION

1.1 Scope of Study

This study has investigated engineering and financial feasibility of reinstallation of hydroelectric power production at Mine Falls on the Nashua River in Nashua, New Hampshire.

Alternative systems, sites, markets and finances were evaluated to select the most desirable and financially feasible system. The evaluation of financial feasibility was based on (a) hydrologic and hydraulic characteristics of the Nashua River and the damsite, and (b) the market value of generated power. The results of the foregoing analyses served as the primary bases for comparison of alternatives and ultimate selection of the recommended plan.

1.2 Authority

The authority for this study is contained in a resolution by the United States Senate Committee on Environmental and Public Works of 6 December 1978 at the request of Senator John A. Durkin of New Hampshire. A copy of this resolution is attached hereto in Appendix A.

1.3 Sources of Information

The Pre-Reconnaissance Report "Jackson Mills and Mine Falls Dams, Hydroelectric Feasibility", June 1979, prepared by Anderson-Nichols and Company, Inc. and the Corps of Engineers under Contract DACW33-78-C-0345 Work Order No. 4 formed the basis for this report.

Information was obtained from Federal agencies including, the U.S. Geological Survey, the Federal Insurance Administration, and the Federal Energy Regulatory Commission. At the state and local level, information was compiled from the New Hampshire Water Resources Board, Water Supply and Pollution Control Commission, Department of Resources and Economic Development, Fish & Game Department, the Governor's Council on Energy, the Public Utilities Commission, the Nashua Mayor's office, Assessor's office and Planning Board. Nongovernment sources included the Public Service Company of New Hampshire, Merrimack Valley Textile Museum, James River-Pepperell Inc. and the Energy Law Institute at the Franklin Pierce Law Center who provided useful information to this study. Their cooperation is appreciated.

2.0 EXISTING FACILITIES AND BACKGROUND OF MINE FALLS DAM

Mine Falls Dam is situated on the Nashua River approximately 5.3 miles upstream from the confluence of the Merrimack and Nashua Rivers. The dam is 1.3 miles upstream of the F.E. Everett Turnpike crossing of the Nashua River and about 4.0 miles above Jackson Mills Dam. The river flows easterly at this damsite. The dam is accessible by dirt roads from Mine Falls Park or from Route 111 (West Hollis St.) in Nashua. The site is shown on the Vicinity Map (Figure 1).

The dam and associated canal system were constructed between 1822 and 1825 to provide power for the Nashua Manufacturing Company mills at the downstream terminus of the canal. A new gatehouse was built at the head of the canal in 1886. The present dam is of "gravity" type and is of quarried masonry with a concrete cap. The north end wall of the dam is of concrete and dates from 1926, while the south abutment is of rubble masonry and may be of the original construction.

Mine Falls Dam and appurtenances consist of a stone masonry, gravity-type structure 325 feet in length with a stone masonry spillway crest. The crest elevation is a 154.9 feet (NGVD) with a crest length of 145 feet. The south abutment consists of cemented stone masonry with a concrete cap and is about 22 feet long. A plugged 2.5' X 3.5' flume penetrated the stone masonry. The south "backward J" training wall has a total length of 125 feet and leads to the gatehouse. The dam is approximately 24 feet in height. The outlet works consist of five wooden gates approximately six feet wide by 9.5 feet high. Three of the five gates are plugged with prefabricated concrete blocks bolted in place. One gate is jammed and inoperable. The fifth gate controls releases into the canal and mill pond. The outlet invert is at elevation 141 (NGVD) and is currently maintained in a partially opened position. There is a head loss of approximately 7 feet through the gatehouse.

The Phase I Inspection Report prepared for the Corps of Engineers in March 1979 has determined that the dam is in fair condition. It has been recommended that the following measures be taken at the dam: reconstruct the north canal wall on competent foundation, repair cracks in north end wall of the dam, and perform a technical inspection of the dam annually.

The dam is owned by the City of Nashua and inspected at frequent, though irregular, intervals by the Nashua Department of Parks and Recreation. No operation of the dam is performed and no formal maintenance program exists (Reference 1). The land use and apparent ownership of abutting properties were obtained from the tax maps and inventory card file available in the Nashua Assessor's office. The information is presented on Plate 1 (Appendix F).

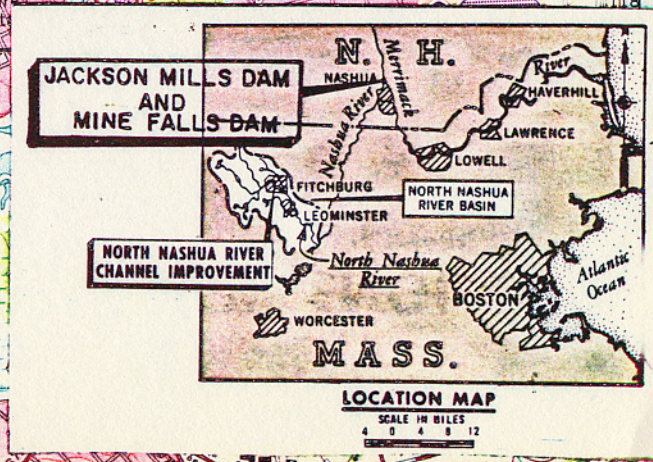


Figure 1

The Land and Water Conservation Fund Act of 1965 (Public Law 88-578) provides: (1) matching grants for state recreation planning and land acquisition and development, and (2) acquisition of lands for federally administered parks, wildlife refuges and recreation areas. It is administered by the Heritage Conservation and Recreation Service (formerly Bureau of Outdoor Recreation) of the Department of the Interior. About 60% of the total fund provides grants to states and their cities, counties, towns, etc., for the acquisition and development of public outdoor recreation areas and facilities. Lands of like dollar value and recreational significance can be purchased to replace any land that is removed from recreational use. Consideration of these regulations must be made as Mine Falls Park was purchased using such funding.

Restoration of the Mine Falls Dam for hydropower redevelopment should incorporate provisions to minimize any temporary or permanent disturbance to the park; therefore, the architecture and landscaping should be conceptually compatible and in harmony with the park atmosphere. Mine Falls Park is intended to be a recreational area providing boating, swimming, canoeing and hiking. For these reasons, the water level and flow through the pond and canal must be maintained at a desirable level to promote and encourage a majority of these activities.

3.0 ENVIRONMENTAL SETTING

3.1 General

The Nashua River watershed includes 34 communities in Massachusetts and New Hampshire. The river is 57 miles long with the South Branch flowing from the Wachusett Reservoir in Clinton, MA, where it continues north to Lancaster, MA. joining the North Branch and forming the main stem. From here the river flows north to Nashua, NH, and ultimately into the Merrimack River. For three-fourths of its length it flows through country consisting of fields, wetlands and forests. (Reference 2).

Mine Falls Dam is located in a semirural area southwest of the city of Nashua, NH, approximately 5.3 miles upstream from the confluence of the Merrimack and Nashua Rivers. At this point the waters are diverted into a canal which parallels the Nashua River through most of the park. (Reference 2). Immediately below the dam there is a stretch of rapids and some small undeveloped islands. Located above the dam is the Mill Pond which leads into the canal system. This area is known as Mine Falls Park where canoeing, fishing, hiking and bicycling are permitted. The park is covered with fairly dense stands of white pine, hemlock and oak offering a pleasant forest atmosphere despite the fact that its location is close to the downtown area of Nashua.

3.2 Topography

The basin has a total drainage area of 529 square miles, with 88 square miles being in New Hampshire, and 441 square miles in Massachusetts.

The relief of the area varies with gentle slopes and low hills on the eastern side of the main stem valley and steeper topography on the highland edge on the west. The Wachusett range divides the subwatershed of the southern region. The highest peak in the watershed is Mt. Wachusett with an elevation of 2,006 ft. (NGVD). (Reference 3).

From the central valley of the main stem of the Nashua River to the limits of the watershed, the landscape is broad, forested and rural, with small towns and cities scattered throughout.

The gradient of the river is gentle, with the main stem dropping 105 feet from Lancaster to the Merrimack River 35 miles downstream. (Reference 3).

3.3 Geology

The bedrock of the Nashua River watershed is mostly granite, and is covered with a mantle of soils consisting of sand, gravel

and till which was placed as glacial drift or as interglacial deposits. The basin is underlain by quartzites and schists which were metamorphosed during the collision of the North American and European plates in the Early Paleozoic period, causing the general north-south orientation of the basin. (Reference 2).

In the central valley of the watershed, deep sand and gravel deposits are found at many places. Till and bedrock generally occur in the shallow areas.

Soils present in the watershed include clay, peat and deep sandy loams. Most of the river has between 6 and 8 feet of sludge covering the bottom which may also extend a short distance up the banks at various places.

3.4 Water Quality

The entire length of the Nashua River in New Hampshire has been assigned an objective water quality standard of Class C by the New Hampshire Water Supply and Pollution Control Commission. Class C waters are suitable for boating, fishing and industrial water supply. Present water quality conditions in the river, however, do not meet the required criteria for Class C waters. Based upon data collected by the State of New Hampshire in 1977 and 1978 four miles upstream from Mine Falls Dam at Hollis, New Hampshire, high concentration of total coliform bacteria and phosphorous are primarily responsible for the degradation. No data is available for the immediate area around Mine Falls Dam. The bacterial contamination is of both human and animal origins probably emanating from nonpoint sources and urban runoff. Concentrations of nitrogen and phosphorous are very high, and biological response is active with chlorophyll "A" levels typically about 30 mg/M³ and as high as 150 mg/M³. Daytime dissolved oxygen levels are always above 6 mg/l; pH varies within 0.5 units of neutrality; and suspended solids range up to 15 mg/l.

In support of the development of a water quality management plan for the Nashua River Basin, sediment sampling and analysis was performed in 1973 by Camp Dresser & McKee, Inc. at two sites behind the Jackson Mills Dam. This survey revealed the existence of two types of PCB's, dieldrin, DDT and trace metals including aluminum, chromium, copper, mercury, lead and zinc in the sediments. The chlorinated hydrocarbons are very insoluble in water, with saturation concentration of 1 to 2 (parts per billion), and toxic concentrations were not expected to exist in the water. The trace metals concentrations in the sediments were not expected to induce toxic conditions of metals release.

3.5 Climatology

The Nashua River watershed lies between 42° and 43° north latitudes with prevailing west to east winds, and northerly and southerly

movements of tropical and polar air storm systems moving from west to east cause local variations in temperature and precipitation.

Normal annual precipitation at Nashua, NH, is 42 inches, and the average annual snowfall is 55 inches. The mean winter and summer temperatures are 30° F and 70° F, respectively.

3.6 Aquatic Ecosystem

The nearest Great Ponds (more than 10 acres) in the study area are in Hollis, NH, approximately eight miles south of Nashua. They are: (1) Flints Pond, 48 acres in size and private with no access or use; and (2) Rocky Pond, 46 acres in size and also private with no access or use.

The area of the Nashua River which includes the Mine Falls Dam has not been stocked with trout by the NH Fish and Game Department. A short-term fishery investigation was conducted on the Nashua River by the State Fish and Game Department during the summer of 1974. Four stations were sampled downstream of the Mine Falls Dam in the area between the crossing of the Everett Turnpike and Runnell's Dam. The catch consisted of warmwater and non-game fish species, and was representative of those types of species which are found in the New Hampshire portion of the river. Brown and yellow bullheads were the most numerous species netted. (Reference 4). Table 1 lists those fish netted in the survey. It did not include any stations downstream from the Mine Falls Dam to the confluence of the Merrimack River.

There is a potential to establish a fishery for smallmouth bass and related warmwater species. However, the water quality of the river must improve from its present state in order for management of a successful warmwater fishery.

In a subsequent survey performed in the summer of 1975, approximately 250 crayfish were live-trapped in the Nashua River at the Runnells Dam. (Reference 5). However, no other species were sampled for in this survey.

According to the Nashua River Watershed Association, the only areas in the watershed where gamefish are found are in the Nissitissit and Squannacook Rivers which are tributaries of the Nashua River, and are located south of Nashua, NH, in Pepperell and Townsend, MA, respectively. Rainbow trout, brook trout, brown trout, bass and pickerel are most commonly found in these rivers. However, the Nissitissit and Squannacook Rivers are well beyond the scope of the study area of Mine Falls.

3.7 Terrestrial Ecosystem

Within the overall area of the watershed, the vegetative cover is primarily second-growth mixed hardwood/softwood forests. White

Table 1

List of Fish Netted in the Nashua River, August 1974,
N. H. Fish and Game Department

Yellow Bullhead
Brown Bullhead
Black Crappie
Golden Shiner
Common Sunfish
Common White Sucker
Blue Gill
Yellow Perch
Carp

Ictalurus natalis
Ictalurus nebulosus
Pomoxis nigromaculatus
Notemigonus crysoleucas
Eupomotis gibbosus
Catostomus commersoni
Lepomis macrochirus
Perca flavescens
Cyprinus carpio

pine, red pine and hemlock are the common softwood species, and the common hardwood species include red maple, silver maple, white oak, willow, slippery elm and birch. In 1972, between 70 and 75 percent of the total area of the watershed consisted of forests and primarily wooded land. (Reference 3).

Common shrubs found along the streamsides and in wetlands are button bush, sweet viburnum, witch hazel, blueberry, alder, sumac and marsh lady slippers.

In Mine Falls Park, approximately one mile downstream from the dam, there is a mixture of an old mature forest in a relatively dry area and a bottomland forest. Table 2 lists the species present in this area. The bottomland floodplain is toward the canal side, with the dominant species consisting of jewel-weed, ferns, red maple and Virginia creeper. As one gets closer to the river, the terrain changes to a well-drained slope which is fairly steep. There is a dominant understory of hornbeam, with scattered stands of mature pine and oak.

Also present are those species which are typically found in relatively damp areas such as mountain laurel, lady slippers and low bush blueberry.

The area around Mine Falls Dam is an old moist forest with a north facing slope. Hemlock is the dominant species on this side of the river. There are also many good-sized stands of oak and white pine, with the area sloping fairly steeply down towards the river. The diversity of this area is small which is indicated by the age of the stands, and also by the fact that there has not been any type of disturbance on the site for years. Table 3 lists the species found in this area.

Small mammals are very common along the riverbank where development is not heavy and include raccoon, woodchuck and possibly otter and beaver. In the wooded areas chipmunks, squirrels, mice, foxes and shrews can be found.

Common waterfowl species include mallard and black ducks which can be found in Mine Falls Pond immediately upstream from the dam.

The Mine Falls area provides good habitat for a variety of birds, including kingfishers and hawks. The park provides good cover and habitat because of the diversity in vegetational cover around the canal and the river which ranges from wet bottomland types to mature softwoods and hardwoods.

Table 2

Vegetation Approximately One Mile Downstream From Mine Falls Dam

| | |
|------------------------------------|------------------------|
| <u>Acer rubrum</u> | Red Maple |
| <u>Ulmus americana</u> | American elm |
| <u>Pinus strobus</u> | White pine |
| <u>Quercus alba</u> | White oak |
| <u>Impatiens pallida</u> | Jewelweed |
| <u>Cornus alterniflora</u> | Alternate-Leaf Dogwood |
| <u>Parthenocissus quinquefolia</u> | Virginia Creeper |
| <u>Tilia americana</u> | American basswood |
| <u>Ostrya virginiana</u> | Hornbeam |
| <u>Picea glauca</u> | White Spruce |
| <u>Solanum dulcamara</u> | Bittersweet Nightshade |
| <u>Quercus rubra</u> | Red oak |
| <u>Acer saccharum</u> | Sugar maple |
| <u>Viburnum acerifolium</u> | Mapleleaf Viburnum |
| <u>Taxus canadensis</u> | American Yew |
| <u>Berberis thunbergii</u> | Japanese Barberry |
| <u>Corylus americana</u> | American Hazelnut |
| <u>Rubus sp.</u> | Raspberry |
| <u>Prunus sp.</u> | Cherry |
| <u>Kalmia latifolia</u> | Mountain laurel |
| <u>Vaccinium sp.</u> | Blueberry |
| <u>Castanea dentata</u> | American chestnut |
| <u>Betula lenta</u> | Black birch |
| <u>Gaultheria procumbens</u> | Redberry Wintergreen |
| <u>Cypripedium acaule</u> | Lady's Slipper |
| <u>Lycopodium</u> | Ground pine |

Table 3

Vegetation Around Mine Falls Dam

Hamamelis virginiana

Quercus alba

Quercus rubra

Kalmia latifolia

Castanea dentata

Acer rubrum

Betula papyrifera

Pinus strobus

Tsuga canadensis

Common Witch-Hazel

White Oak

Red Oak

Mountain Laurel

American chestnut

Red maple

American white birch

White pine

Eastern hemlock

3.8 Cultural Resources

Though no prehistoric sites are reported in the immediate vicinity of the Mine Falls project area, local histories refer to 17th century mining of lead for bullets on Mine Island, by the Pennacooks. The area around the falls would have been a likely camping place for both prehistoric and contact period inhabitants of the region, particularly during times of anadromous fish runs. The riverbank immediately below the falls is frequently flooded, poorly drained soils with numerous glacial erratics and bedrock outcrops, and would be unlikely to contain prehistoric resources. The level area at the top of the river terrace, however, is well-drained sandy, loam and much more likely to contain prehistoric or contact period archaeological sites.

In 1682, Hezekial Usher attempted to mine lead and bog iron on the island, but did not obtain sufficient quantities to continue operations. A mill was built at the falls before 1700, and a small settlement developed in the area during the 18th century.

A dam and canal were constructed between 1822 and 1825, to provide power for the Nashua Manufacturing Company mills, located in the center of the city. A new gatehouse was built at the canal head in 1886. The present dam is of "gravity" type and is of quarried masonry with a concrete cap. It may date from the same time as the gatehouse rebuilding (1886). The north end wall of the dam is of concrete, and dates from 1926, while the south abutment is of rubble masonry, and may be original construction. A sluice of 2.5 ft. x 3.5 ft. x 30 ft. upstream length is built into the dam near the south abutment.

The 19th century features of the Mine Falls Dam and canal may be eligible for inclusion in the National Register of Historic Places, as an example of an essentially intact early hydro-power system with considerable importance in local and regional history. There is a slight possibility that some remains of the 17th and 18th century waterpower features at this site were incorporated within the 19th century features at the site.

3.9 Rare and Endangered Species

The following plant species have been reported to be present at stations in the area of Nashua, NH. They are considered rare by the New England Botanical Club as reported in the 1978 publication from NEBC entitled: "Rare and Endangered Vascular Plant Species in New Hampshire." However, as some of the stations date back to the 1800's, the presence of these plants is questionable. They were not found in the vegetation surveys done for the listings provided in Tables 2 and 3.

It should be noted that, at present, none of these are on the Federal list of endangered plants for this area or are they being proposed for inclusion on this list.

Zizania aquatica L. var. angustifolia Hitchc - wildrice

Allium canadense L. - wild garlic

Prunus americana Marsh - American plum

Tephrosia virginiana L. Pers. - Goat's Rue

Xanthoxylum americanum Miller - Northern Prickly Ash

Viola pedata L. var. lineariloba DC - Birdfoot violet

No rare and/or endangered faunal species are known to exist in the vicinity of the Mine Falls Dam.

4.0 HYDROLOGY

4.1 Watershed Description

The City of Nashua is located on the southern New Hampshire boundary approximately 12 miles north of Lowell, Massachusetts. The city straddles the Nashua River at its point of discharge to the Merrimack River. The city is located on a gently sloping low plateau that is characterized by stratified and unstratified material of silt, sand and gravel that were deposited by the meltwaters of a retreating glacial ice sheet. Elevations range from approximately 100 feet (NGVD) at the mouth of the river to 426 feet NGVD on Gilboa Hill, the highest point in town. The Nashua River basin has a total watershed area of 529 square miles located within the states of Massachusetts and New Hampshire. Portions of the watershed lie in the following counties: Worcester and Middlesex Counties, Massachusetts and Hillsborough County, New Hampshire. The Nashua River has two principal branches: the south or main branch originating north of Worcester at the Wachusett Reservoir Dam in Clinton and the north branch formed by the junction of the Whitman River and Flag Brook in West Fitchburg. The two branches join in Lancaster, Massachusetts, and flow north-easterly to the Merrimack River at Nashua, New Hampshire.

Though the gross watershed area of the Nashua River is 529 square miles, the Wachusett water supply reservoir diverts the runoff from 115 square miles, or 21 percent of the watershed, out of the basin to the Boston MDC water supply system. With the exception of very infrequent spillage, the only discharge from Wachusett Reservoir to the Nashua River is a prescribed minimum release of about 3 cfs. Therefore, the net effective drainage area of the Nashua River is 414 square miles. The most westerly headwater region of the watershed lies on the easterly slope of the "Berkshire" hills resulting in a hydrologically "flashy" North Nashua River. However, the mainstem Nashua River has a very flat gradient, for New England Rivers, with extensive swamps and natural valley storage areas, resulting in an overall hydrologically "sluggish" river basin.

The average annual temperature in the Nashua River basin is about 50° F varying from a seasonal average in the winter of about 30° to 70° in the summer. Extremes range from highs of near 100° F to lows in the minus 20°s. There are about 150 days per year with temperatures below 32° F. Average annual precipitation is about 42 inches, occurring quite uniformly throughout the seasons; however, some of the winter precipitation occurs as snow with an average annual snowfall of about 55 inches.

4.2 Streamflow

The average annual runoff in the Nashua River basin is about 24 inches of nearly 60 percent of annual precipitation. This amount of runoff is equivalent to an average runoff rate of between 1.7 and

1.8 cfs per square mile of drainage area, resulting in a total average flow at Nashua, from the net drainage area of 414 square miles, of about 730 cfs. Though precipitation is quite uniformly distributed throughout the year, the melting of the winter snow cover results in about 40 percent of the annual runoff during the spring months - March, April and May. Flows are usually lowest during July, August and September.

The U.S. Geological Survey has recorded flows on the Nashua River at East Pepperell, Massachusetts, (net drainage area equals 316 square miles) continuously since 1935. The long term average at this station is 557 cfs. Average monthly and maximum and minimum daily flows at the station site are listed in Table 4. The peak discharge at the gage was 20,900 cfs on 20 March 1936. The minimum flow was 1.1 cfs on 13 August 1939. A flow duration curve for the period of record (1936-1977) is shown in Figure B-1 (Appendix B). The four other flow-duration curves presented in Figure B-1 illustrate the wettest and driest years on record, 1956 and 1965, respectively, and the months of April and September for the period 1936-1971. These curves show the greater seasonal and annual variations in flow.

Because the study site at Nashua is located considerably downstream of the East Pepperell gaging station, with an intervening 89 square miles of drainage area, a flow duration curve at Nashua was developed based on the East Pepperell curve adjusted for the added area. Adjustment was based on intervening drainage area and mean basin elevation using the procedure presented by S.L. Dingman (Reference 6). This procedure resulted in lower flows at Nashua than would be computed using a ratio of net drainage area and was, therefore, considered a method providing conservative estimates for the purpose of this feasibility study. The adopted flow duration curve for the Nashua River at Nashua is shown as Figure B-2 (Appendix B). Although a small increase in drainage area occurs between Jackson Mills Dam and Mine Falls Dam, the same flow duration curve was considered applicable at both locations.

The foregoing flow analysis excludes consideration of flow maintenance required by the recently revised National Pollution Discharge Elimination System (NPDES) provisions for the river at the James River Pepperell Company just upstream of the USGS gage at East Pepperell, Massachusetts. According to the Company's NPDES permit, effective until February 1982, the James River - Pepperell Company is required to pass a minimum of 60 cfs or a flow into Pepperell Pond. Prior to 1977, their operation was required to pass approximately 15 cfs. Thus, it is possible that the low flow portion of the computed flow duration curve will change, however, any change would be in the very low flow range of the duration curve and should have no effect on the estimates of hydropower potential.

TABLE 4

AVERAGE MONTHLY FLOWS (1936-1977)
NASHUA RIVER AT EAST PEPPERELL, MA
 (Gross D.A. = 433 sq. mi.)
 (Net D.A. = 316 sq. mi.)

| <u>Month</u> | <u>Avg. Flow (cfs)</u> | <u>% of Annual Runoff</u> | <u>Maximum Daily</u> | <u>Minimum Daily</u> |
|--------------|----------------------------|-------------------------------|--------------------------|--------------------------|
| Jan. | 578 | 8.6 | 5,000 | 2.8 |
| Feb. | 616 | 9.2 | 4,160 | 6.7 |
| Mar. | 1,125 | 16.7 | 19,400 | 6.1 |
| Apr. | 1,247 | 18.6 | 5,340 | 5.5 |
| May | 720 | 10.7 | 2,780 | 5.5 |
| June | 454 | 6.8 | 6,840 | 3.5 |
| July | 260 | 3.9 | 4,550 | 5.2 |
| Aug. | 206 | 3.1 | 3,600 | 2.0 |
| Sept. | 242 | 3.6 | 9,790 | 3.6 |
| Oct. | 269 | 4.0 | 5,530 | 3.4 |
| Nov. | 442 | 6.6 | 4,090 | 3.7 |
| Dec. | 560 | 8.3 | 3,510 | 2.0 |
| Annual | 560 | | 19,400 | 2.0 |

4.3 Hydropower Potential

The hydropower potential of a volume of water is the product of its weight and the vertical distance it can be lowered. Water power is the physical effect of the weight of falling water. It is considered a source of power when it can be feasibly harnessed to perform useful work - particularly turn wheels and generate electricity. The amount of water power developed from any stream, river, or lake is measured primarily by: (1) the available rate of water flow and (2) the head that is available. Both the rate of discharge and the head are quantities which may fluctuate. It is therefore the magnitude of these two quantities and their variability that determine the potential energy of a site and its dependability.

The rate of power generation, at any point in time, "capacity", normally measured in kilowatts, is determined by the classic formula:

$$P = \frac{EHQ}{11.8}$$

where:

- P = Power or capacity in kilowatts
- E = Combined turbine and generator efficiencies
- Q = Rate of discharge in cubic feet per second
- H = Net hydraulic head

The amount of power generation over a period of time, "energy", is normally measured in kilowatt-hours and is equal to the average capacity times the duration of generation.

All studies were made using an assumed average turbine-generator efficiency "E" of 80 percent and net head was taken as the difference between average head pool and tailwater, less any penstock friction loss.

Since the flow duration curve is a measure of the magnitude and variability of flow, the area under the flow duration curve - within the operating limits of the selected facility - establishes the potential average annual energy to be realized at a site. Examples of the computation of average annual energy and capacity are presented in Figures B-3 to B-8 (Appendix B).

Since the flow of the Nashua River at Nashua is quite variable and there is no appreciable regulating storage, the generating capacity at the sites could not be considered "firm" or "dependable" and energy generated would be classified as "fuel-saver" or "secondary". It is noted, however, that though the energy from the sites would not be firm, such generation would be "seasonally dependable" and could therefore be seasonally relied upon in the planned operation of a larger integrated system. For purposes of these studies, no capacity or firm energy benefit was claimed, and all benefits were based on a "secondary" power value of 40 mills per kwh.

5.0 HYDRAULIC TURBINE AND GENERATOR SELECTION

5.1 Hydraulic Turbine

There are two basic classes of hydraulic turbines - impulse turbines and reaction turbines. The fundamental difference is that impulse turbines are driven by the kinetic energy of a high velocity jet, whereas, reaction turbines are driven by the combined pressure and velocity of the water.

The impulse design has cost-effective operating characteristics for high heads (800 feet and higher) and, therefore, not suitable for the site in Nashua.

The reaction design includes two basic types of runners - Francis runners and propeller runners. A Francis runner operates at heads from 15 to 1100 feet. However, cost-effective operation requires a head of 100 feet or more, therefore, not suitable for Nashua. The propeller type operates at heads up to 100 feet but is usually cost-effective at heads at or below 60 feet (Reference 7). While early propeller runners had fixed position blades, it was not long before the advantages of being able to adjust the blade angles became recognized. This type of propeller runner is called a Kaplan runner.

With the limited head (less than 40 feet) and wide seasonal variation in flow at the site in Nashua, the most cost-effective unit is considered to be the Kaplan variable pitch blade propeller turbine.

Installation of the Kaplan turbine can be vertical or horizontal; the choice most often depends on head available or the site configuration. A very low head application is more effective for the vertical configuration as the units are often of large diameter and low speed, allowing less excavation for the powerhouse. The horizontal configuration places the drive shaft in the line of the flow through the runner; therefore, the generator must be also within or around the draft tube, or the flow must be diverted between the runner and generator with the drive shaft penetrating the draft tube. The bulb type system has the generator inside a steel bulb with runner downstream. The entire unit is contained within the draft tube. The bulb unit requires more excavation than other applications, and the flows available are at or below the lower limit of standard predesigned units. The application considered most appropriate for the Nashua site was the tube type, with the runner connected to the generator by a shaft penetrating the draft tube. It is available in standard predesigned units for applications involving a wide range of flows and heads encompassing conditions encountered at the site in Nashua.

Studies were made assuming one or two units per site as the flow of the river is too small to warrant additional construction and equipment costs for more units. However, two units per site are gen-

erally recommended due to the greater operating flexibility provided for the varying flow conditions. The upper and lower limit of effective operation of the units was assumed 100 and 50 percent of the design flow which is deemed conservative as present day variable blade units operate quite effectively at flows from 105 percent to less than 40 percent of design. Though the assumption is conservative, the large variation in flow and possible variations in head could reduce the overall average efficiencies of the units. Manufacturers indicate an efficiency of up to 85 percent. For purposes of this study, an average efficiency of 80 percent was assumed. It has also been assumed that in a multiple unit installation, all units will have variable blades, although a potential saving might be obtained if one unit is fixed blade and the other variable.

The selection of turbine size and hydraulic capacity was based on the head and flow characteristics at the site. The selected capacities were those of available "package" units that were considered reasonable levels of design providing realistic plant factors. Further optimization of selected installed capacity may result from more detailed design studies. However, use of available "package" type units should provide economies over custom designs. The selected capacities were at or near the 20 percent exceedance flow value, providing plant factors in the range of 35 to 50 percent. In the case of those Mine Falls installations located on the canal system, the hydraulic capacity was limited to an estimated 600 cfs which is about a 35 percent exceedance flow value which resulted in plant factors in the order of 60 percent. Characteristics of the tube type turbine and generator units were obtained from manufacturer literature that was generally representative of all major manufacturers.

Units with two turbines of unequal size allow for more efficient flow utilization and achieve higher plant factors. While equal-sized units permit slightly less efficient flow utilization, the analyses assume they provide economics of design, maintenance and operation which more than offset the incremental decrease in plant factor. Further in-depth investigations in any final design should be performed to verify these assumptions.

5.2 Generator Selection

Generators are either synchronous or induction types. The synchronous unit is equipped for self excitation and synchronization before going onto the grid, whereas, the induction generator relies on power from the grid for excitation. Induction generators are somewhat cheaper in cost and more applicable to small installations, however, for this feasibility study and at the suggestion of representatives of Public Service Company of New Hampshire, synchronous generators were assumed for the site.

6.0 MARKETING, FINANCING AND MANAGING HYDROPOWER ENERGY

6.1 Establishing a Potential Market

The ideal market for power produced would be to a facility whose electrical energy requirements would closely match the output of the proposed hydroelectric site. Since the plant is a run-of-the-river installation and dependent on the flow of the river, a backup of firm power would be required in the dry months, thus precluding a self-contained system.

Three possible plans are identified for the use of energy produced: (1) sale of total power produced to the grid system, (2) wheeling of power, and (3) direct transmission with provisions for standby power.

With regard to the sale of the total power produced to the grid system, current New Hampshire legislation states that the franchised utility shall buy the entire output of small hydro plants with the rate to be set by the Public Utilities Commission of New Hampshire (PUC). (Reference 8). An order by the PUC on April 18, 1979, set a rate of 4¢/KWH to be paid for the output of a run-of-the-river plant. (Reference 9). Excerpts from the above legislation are contained in Appendix C while the PUC order is contained in Appendix D.

Wheeling is the use of transmission lines owned by the electric utility to transmit power produced at the hydroelectric plant to a location where it can be used. A fee would be charged by the electric utility for this service. In Nashua's situation, this would mean that the power produced at Mine Falls could be wheeled to Nashua High School, Police Station, Public Works Garage or any other municipal building. Recent New Hampshire legislation allows the producer of small scale hydroelectric power to enter into a wheeling agreement with the franchised utility. The Public Utilities Commission of New Hampshire must approve such agreements. (Reference 10). Excerpts from the above legislation are contained in Appendix C. A source of backup power would still be required to firm up the power demanded by the buildings in the dry months. Thus, the City of Nashua could negotiate an agreement with Public Service Company of New Hampshire on wheeling and provisions for standby power.

Direct transmission would involve installing a separate independent grid from the site to distribute energy to the various municipal buildings in reasonable proximity to the site. This would require the installation of new distribution lines to the Nashua High School, Public Works Garage and other designated municipal buildings. Since this would be a separate grid system, the City of Nashua would have to maintain this system. A source of standby power would also have to be provided for the dry months. At the present time, this marketing arrangement is inconsistent with New Hampshire legislation.

Sale of the total power produced to the grid system would appear to be the best overall, since events in the State of New Hampshire are moving toward the stimulus of low-head hydropower production. The simple concept of selling generated hydropower to the Public Service Company through a single metered point provides a readily obtainable source of revenue and a market which can use the total energy generated.

6.2 Financing

The financial scenario developed for hydroelectric development at the site assumed that the City of Nashua would provide funding through 20-year bonds bearing an interest rate of approximately 6%, serviced with a sinking fund established for the life of the bond issue.

The ownership of the site by the City of Nashua, with its non-profit status might require prior clarification or interpretation from the Internal Revenue Service - since any income resulting from the production of hydropower might be taxable.

6.3 Management

It was assumed that the City of Nashua would manage the site, providing inspection, cleaning and maintenance of the trash racks and equipment; and that the operational control of the hydropower generating facility would be fully automatic with no manned control room. Emergency shutdown mechanisms would be provided for the safety and protection of the automatic equipment. Provisions could be incorporated that any technical or mechanical maintenance be performed by a technician provided by the manufacturer of the equipment, or under a service-type policy providing a specialist highly trained to service the equipment.

7.0 EXISTING WATER RIGHTS AND RESTRICTIONS

In New Hampshire, a developer of hydroelectric power, in acquiring his stream-bordering land, has also acquired certain riparian rights for usage of the water. These rights are outlined by the common law riparian doctrine of reasonable use. The ownership of the land bordering the stream gives a developer the right to use the water but not ownership of the water. Every owner of land situated adjacent to a stream who has not sold his water rights, has the right to the natural flow of the stream and to insist that the stream shall continue to run, that it shall flow off his land in its usual quantity, at its natural place and usual height and that it shall flow off his land upon the land below in its accustomed place and at its usual level. (Reference 11).

The City of Nashua acquired from the Nashua New Hampshire Foundation the 325-acre tract of land that currently comprises Mine Falls Park, the Nashua Canal System and the Mine Falls Dam and Gatehouse. The city was conveyed all flowage rights over lands upstream of Mine Falls Dam in Nashua and Hollis and the right to increase the elevation of the dam by 15 feet. (Reference 12). A resolution by the Board of Aldermen of Nashua changed the right to increase the elevation of the dam to 1.5 feet. (Reference 13). The city is required to maintain flow in the canal at a level satisfactory to the Nashua New Hampshire Foundation or its successors.

The City of Nashua was granted a conservation easement by the Nashua New Hampshire Foundation with a restriction to preserve and protect the Nashua River and riparian lands currently owned by the Foundation immediately upstream of Mine Falls Dam along the southern bank of the Nashua River. (Reference 14).

Associated with the Mine Falls Dam is a millpond and canal owned by the City of Nashua. Water may be diverted from the Nashua River into the millpond through an inlet gatehouse adjacent to the dam. Two emergency spillways have been built on the millpond to accommodate increased flows. The spillway lengths are 19.4 and 24.0 feet and are both stoplogged controlled at a present crest elevation of about 148.4 feet (NGVD). The flow into the canal system would be balanced by the capacities of the two emergency spillways and the existing downstream overflow structure.

8.0 PROPOSED ALTERNATIVES

Mine Falls Dam and canal form the southern boundary of Mine Falls Park, with the Nashua River forming the northern boundary. Hydroelectric development at Mine Falls should incorporate provisions to minimize any temporary or permanent disturbance to the park. The potential use of the canal system for swimming, boating and skating demand that strict water-level control must be maintained. Flow velocities in the canal must be maintained at low rates to allow recreational use. The natural beauty of the park must be preserved; therefore, any buildings must be attractive, and clearing of trees must be kept to a minimum.

The Mine Falls alternative hydropower generating sites were selected with the assumption that a portion of or all of the Mine Falls Dam/gatehouse/canal system can be utilized. The possible alternatives are located on Plates 2, 3 and 4 (Appendix F).

Alternative A would require construction of an intake through the dam to transmit the water via penstock along the base of the cliffs on the north side of the river to a powerhouse located at the base of the slope.

Alternative B would require construction of an intake through the dam and penstock along the southern bank of the river for a distance approximately 500 feet downstream of the dam.

Alternative C would require an inlet through the dike on the mill pond. It would transmit the flow to a powerhouse at the head of a tailwater canal which roughly follows an old stream bed presently carrying overflow from the mill pond.

Alternative D would require a tailwater canal aligned as for Alternative C. The penstock and tailwater canal length would be reduced but the inlet would have to be in the old power canal. It is important to note that Alternatives D, E, F, G, H and I will use the canal to carry the flow and that the canal flow should be limited to no more than 600 cubic feet per second. The canal would have to be desilted and cleaned at an expense directly related to the distance required.

Alternative E would be considered if the other canal alternatives prove aesthetically unacceptable as the penstock would utilize the area cut back for the transmission line right-of-way.

Alternative F requires a moderate length of canal and a very short length of tailwater canal.

Alternative G is similar to F but would require more canal and would have reduced accessibility.

Alternative H has been sited beyond the boundary of the park and utilizes a short penstock. It would require an opening of the oxbow for use as a tailrace. The land is owned by the Nashua Foundation and would have to be acquired.

Alternative I would require lining the overflow culvert for penstock stresses, acquiring the mill building and reconstruction of the powerhouse.

Table 5 summarizes the alternatives for decision evaluation. The evaluation has been performed by listing significant decision factors and rating each factor by degree of negative impact on the alternative. The impacts on the evaluation process are rated as none, slight, moderate, considerable and severe and are valued at 0, 1, 2, 3 and 4. The impacts were summed with the smallest total yielding the alternative to be further evaluated. The engineering constraints were varied enough to require several decision categories: Penstock - the impact of total length; New Canal Construction - the total length and depth; Canal Revitalization - the total length; and reinforcement of the old power canal; Water Level Control - the increased cost of maintaining water surface elevation; Hydraulic Capacity Limits - the impact of physical constraints on flow; and Access - the impact on construction. The other decision categories were: Aesthetic - the impact on the natural setting and the architectural requirements; Historical/Archaeological - the impact of known or potential historical or archaeological sites; Ownership - the impact of utilization of non-city property.

The method of selection involved subjective consideration by the study team. The selection process suggested that two plans be looked at in further detail: (1) Alternative B - hydroelectric development at the damsite and (2) Alternative F - development along the canal. Although only one plan of development is possible, analysis and discussion for both plans is presented in the following sections to provide comparative information. Figure 2 is an aerial photograph showing the locations of Alternatives B and F.

TABLE 5
ASSESSMENT OF ALTERNATIVES
MINE FALLS DAM

| <u>DECISION IMPACTS</u> | <u>ALTERNATIVES</u> | | | | | | | | |
|---------------------------|---------------------|----|----|----|----|----|----|----|----|
| | A | B | C | D | E | F | G | H | I |
| Penstock | 4 | 3 | 2 | 1 | 3 | 0 | 1 | 1 | 4 |
| New Canal Construction | 0 | 0 | 4 | 3 | 0 | 1 | 0 | 2 | 0 |
| Canal Revitalization | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 4 | 4 |
| Water Level Control | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Hydraulic Capacity Limits | 0 | 0 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| Access | 4 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 |
| Aesthetics | 3 | 3 | 4 | 4 | 1 | 2 | 2 | 0 | 0 |
| Historical/Archaeological | 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 2 |
| Ownership | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 |
| TOTAL | 16 | 13 | 19 | 19 | 14 | 13 | 15 | 17 | 20 |

Degree of Impact
0 - None
1 - Slight
2 - Moderate
3 - Considerable
4 - Severe

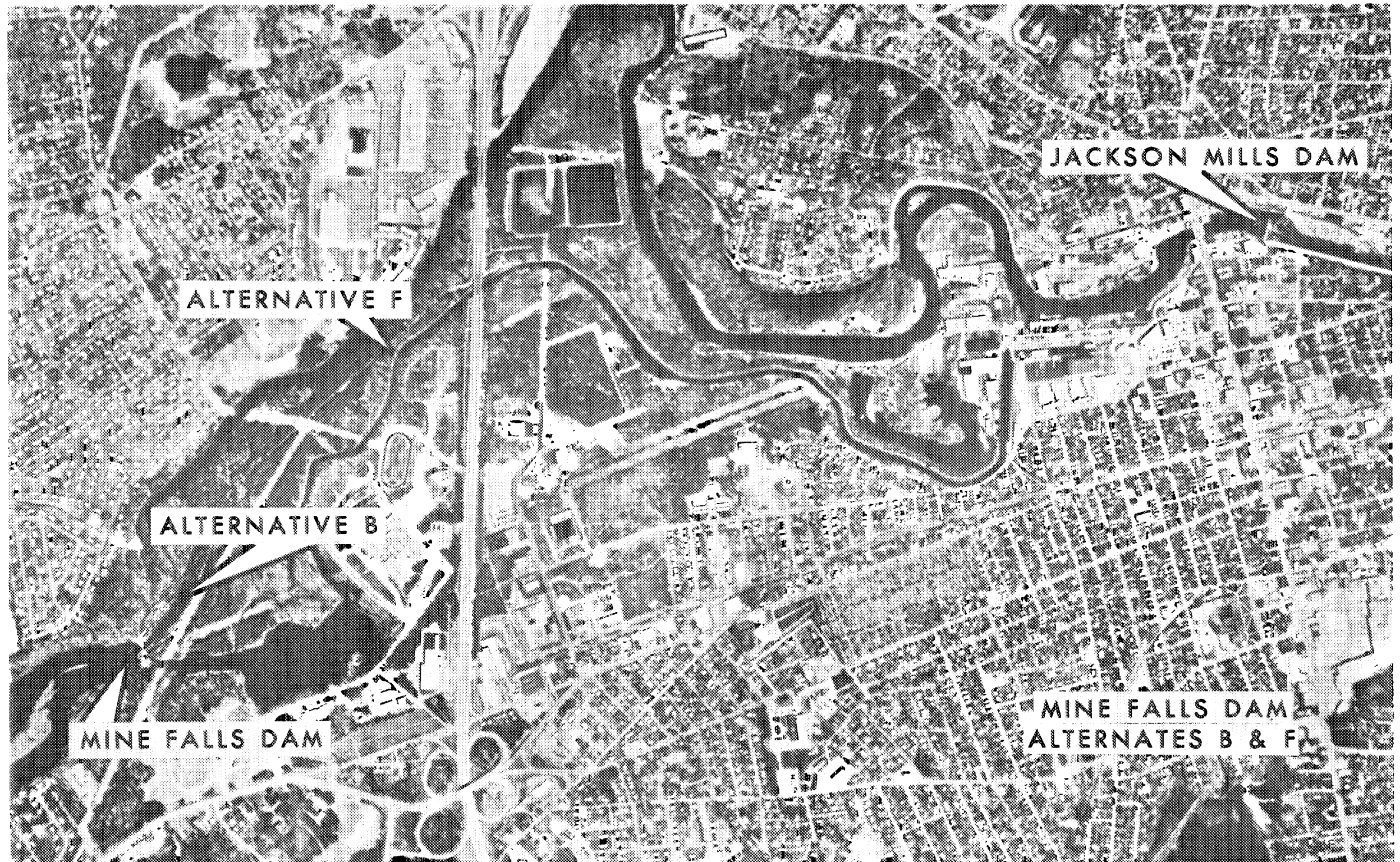


FIGURE 2

9.0 ENVIRONMENTAL CONSIDERATIONS OF THE ALTERNATIVES

For all alternatives associated with Mine Falls, the discussion of impacts are based on the fact that the dam would be operated as a run-of-the-river facility. The pool behind the dam would not normally be drawn down below the elevation of the spillway for purposes of power generation. The fluctuation of Mine Falls Pool does not normally exceed 0.5 to 1.0 feet per hour. If the pool had to be used during an emergency situation during low flow periods, the pool would be drawn below spillway crest for a short period of time. This drawdown would be 0.5 ft. per hour. (Refer to Section 10: Hydrologic Engineering Analysis for discussion of project operation). The level of the pond could be affected by low water during the summer months as a result of low rainfall.

The impacts that would be associated with Alternative B are mostly those concerned with the terrestrial environment. As was described in Section 3.0, the project area contains scattered stands of mature pine and oak, in addition to bottom-land type species close to the river.

The placement of the 500' exposed penstock would result in moderate impacts to the existing environment. Vegetation would have to be removed to accommodate the penstock and for accessways to the construction area. This would also be true for the powerhouse site.

After the project has been completed, understory vegetation would eventually grow back in the disturbed areas. However, the degree of impact on the stands of pine and oak would depend upon the number of trees that would have to be removed. Measures should be taken to save as many of these stands as possible in order to keep the area similar to its present state. Mine Falls Park is highly used by local residents for bicycling, hiking, and general recreation activities.

In all phases of construction, there would be disruption to resident wildlife populations near the area due to noise and physical construction activities.

Wildlife in this area would be temporarily or permanently displaced, with some returning after construction is completed and the facility is operating. These species would include mice, shrews, squirrels, chipmunks, rabbits, and raccoons. Noise from the powerhouse could discourage some animals from returning to this area and also birds would be affected to a minor extent.

Should construction activities be carried out during the spring of the year, some nesting sites for waterfowl and terrestrial birds could be disturbed. During other times, because of the loss of some of the vegetation in the area, food and cover resources would be reduced for wildlife. This displacement and reduction in food sources could put pressure on the existing mammal and avian populations which are assumed to be operating at maximum carrying capacity. Local increases in the surrounding populations would increase feeding in these areas and may eventually reduce productivity.

Any fluctuations in the pool level (Mine Falls Pond) could cause some unpleasant odors as a result of sections of the banks being exposed. The water level change would not seriously affect fish in the pool. Any submergent and emergent vegetation growing in the fluctuation zone could possibly be desiccated as a result of being exposed. Seasonal variation in the pool is 3 ± feet. Variations in the maximum pool due to power generation would be 1.5 feet. Fluctuations occur in the normal zone, therefore, impacts due to generation of power would be minor.

Impacts on the aquatic ecosystem would also be minor. There would be a temporary increase in turbidity during construction in the downstream area of the dam, however, this would have little or no effect on the existing fisheries.

The site of the proposed Alternative B powerhouse, and penstock is an unlikely location for significant archaeological resources, as it is on frequently flooded ground near river level, with fairly poor drainage, surface bedrock, and numerous glacial erratics.

The penstock route involves modifications to Mine Falls Dam or its south abutment. As the 19th century power canal system may be eligible for the National Register of Historic Places, detailed archive and literature research should be undertaken to determine the historic significance of the dam. Mitigation, if needed, would probably involve design of the headgates and penstock to aesthetically complement existing features, and/or possible recording of subsurface features of the existing dam found during construction.

According to Resolution R-78-104, 1978 by the Board of Aldermen of the City of Nashua, the City of Nashua has the right to increase the elevation of the dam to 1.5 feet. There would be substantial environmental impacts should this be done. The level of the pond behind the dam would be raised accordingly, thereby causing the shoreline to be inundated to a higher level. Waterfowl nesting sites that may be located on the islands in

the pond or along the shoreline would be inundated. There would be effects on groundwater and a possible increase in flooding during spring run-off. Habitat would be lost for those mammals that live along the shore of the pond such as muskrats and otters. Other impacts would include effects on vegetation close to the pond which would not be able to grow as a result of the increased pool elevation, and possible short term increases in food supply for fish as a result of inundating shoreline vegetation that normally would not be available. A thorough analysis of the existing environmental parameters and resultant impact analysis on these parameters would have to be accomplished should it be decided that the dam has to be raised.

Impacts associated with Alternative F would be similar to those discussed for Alternative B and would be moderate in nature. However, there are different types of vegetation which would be disturbed at this site. The dominant species in this area is hemlock, in addition to the stands of oak and white pine. In order to place the 40' penstock, construct the powerhouse, and provide accessways some of these trees would have to be removed.

As with Alternative B, the aesthetic appeal of the area must be considered and measures should be taken to keep the area as aesthetically pleasing as possible.

The loss of vegetation would also result in a loss of some food sources for resident wildlife and thereby cause relative increases in the surrounding populations. This would increase browsing in these areas and may eventually reduce productivity. Some cover and habitat for avifaunal species in the area would be removed permanently and/or disturbed during construction.

Fluctuations in the pool level due to the generation of power would be the same as that for Alternative B.

Also, there would be a temporary increase in turbidity in the river due to construction activities. This will have little or no effect on the fisheries.

Similar amounts of terrestrial habitat will be adversely affected by this alternative as for Alternative B because of the location of the penstock and powerhouse within the forested area of Mine Falls Park.

Noise from construction activities and also from powerhouse operation would most likely deter any small mammals from feeding along the riverbank for a short period of time.

The soil in this area is similar to that at Alternative B. A medium brown band of sandy loam of about 10 cm. thickness is found between the upper 10 cm. of the A Horizon and the orange brown subsoil. This indicates a short period of early harrowing or plowing by draft animals, probably prior to the canal construction (1822-25). The river terrace is about 15 ft. in height in this area, while the canal bank is elevated 20 ft. above the terrace by an artificial dike. The canal appears to be a simple ditch, about 100 ft. wide x 10 ft. maximum depth, without any stone lining visible above present water level.

The area of Alternative F has slightly less archaeological potential than Alternative B, due to greater distance from the falls. However, the prehistoric archaeological potential is still fairly high, and a cultural resource reconnaissance is recommended in the area if this alternative is selected for development.

10.0 HYDROLOGIC ENGINEERING ANALYSIS

10.1 General

Hydropower at Mine Falls could be developed either at the Mine Falls Dam (Alternative B) or its associated canal system (Alternative F). A range of alternative developments were considered, both at the dam and on the canal system, and development at the dam appears most practical and engineeringly feasible; since it would not disturb or be associated with the operation, preservation and maintenance of the old and delicate canal system. However, since the finally selected plan may be based on a multifaceted decision process, not limited to engineering feasibility alone, information is presented for two plans: (1) a plan of development at the dam and (2) a plan of development on the canal. Though only one plan of development is possible, analysis and discussion are presented for both plans to provide comparative information.

10.2 Mine Falls Damsite Development (Alternative B)

The dam at Mine Falls which spans the Nashua River about 4 miles upstream of the Jackson Mills dam is a stone masonry structure sited on bedrock. The dam has an ungated overflow spillway 145 feet long with the crest at elevation 154.9 feet NGVD. Presently, all the flow of the Nashua River, averaging 600 to 700 cfs, passes over the dam, with the exception of only about 40 cfs which is discharged through the adjacent Mine Falls canal system. Flows over the spillway fall about 14 to 16 feet into the bedrock controlled downstream river channel. The river channel is quite steep downstream of the dam with white water rapids, and the river flow descends an estimated additional 15 feet in a distance of about 500 feet downstream of the dam. Of the various alternatives considered for power development at this dam, Alternative B appears to be the most practical. This plan consists of siting the turbine-generator facility about 500 feet downstream on the right hand edge of the river, and extending an exposed penstock from the right abutment of the dam along the river edge to the power facility, thus permitting the realization of a gross hydraulic head of about 29 feet or a net head of about 26.5 feet after deducting penstock losses.

The recommended installation at this site would consist of twin 1250 mm, variable blade, tube type turbines each capable of discharging 330 cfs at maximum blade angle under a head of 26.5 feet. The units would be equipped with synchronous generators with not less than 590 kw capacity each. The total hydraulic capacity would therefore be 660 cfs at a head of 26.5 feet, capable of generating 1180 kw of power. The potential average annual "energy" production would be 5,540,000 kwh, at a 0.53 plant factor. Pertinent data on this plan is listed in Table 6. The twin 1250 mm units were recommended after a cursory analysis of both single and two unit installations of

TABLE 6

MINE FALLS
DAMSITE DEVELOPMENT (Alternative B)
PERTINENT DATA

| | |
|---|---|
| 1. Number of Units | 2 |
| 2. Size of Units (mm) | 1250 |
| 3. Hydraulic Head (feet) | 26.5 |
| 4. Hydraulic Capacity per Unit (cfs) | 330 |
| 5. Total Hydraulic Capacity (cfs) | 660 |
| 6. Penstock Length in Feet | 500 |
| 7. Diameter in Feet | 9 |
| 8. Generator Type | Synchronous |
| 9. Generator Capacity | 590 kw each - 1180 kw total |
| 10. Potential Annual Generation | 5,540,000 kwh |
| 11. Plant Factor | 0.53 |
| 12. Spillway Crest Elevation (NGVD) | 154.9 |
| 13. Spillway Length (feet) | 145.0 |
| 14. Headwater Pool (acres) | 170-190 |
| 15. Seasonal Variations in Pool Elevation | 1.6 feet (155.6-157.2 NGVD) |
| 16. Maximum Variations in Pool Elevation | 7+ feet (in 1936) (162.0-154.9 NGVD) |
| 17. Rate of Change in Stage (ft/hr) | 0.5 |
| 18. Maximum Pool Variations Due to Generation | 1.3 feet |
| 19. Rate of Variation Due to Generation (ft/hr) | 0.3 |

varying size. As stated earlier, installations with two turbines of unequal size allow for more efficient flow utilization; however, it was assumed that equal sized units would provide economics of design, maintenance and operation which would more than offset any inefficiencies in flow utilization. A comparative analysis of twin 1250, 1500 and 1750 mm units indicated that, of the three capacities, the recommended installed capacity provided by the twin 1250 mm installation was the most economically feasible, based on current costs and energy values. Pertinent information for a range of unit sizes and combinations is summarized in Table 7. Typical flow duration analyses are illustrated on Figures B-3 through B-5 (Appendix B). All potential energy calculations were made assuming a continuous 40 cfs diversion through the canal system.

Discharge at the existing Mine Falls Dam is mainly over the 145-foot long spillway with approximately 40 cfs discharged through the associated canal system. The spillway crest is at elevation 154.9 feet NGVD and the average flow of 600 to 700 cfs produces about 1.3 foot head on the dam creating an average head pool level of about 156.2 feet NGVD. Average seasonal fluctuations in the pool vary from about spillway crest (154.9 NGVD) to about 2 feet (156.9 NGVD) during the wetter spring runoff months. The peak level of the Mine Falls pool occurred in March 1936 with a head of 7.1 feet (162.0 NGVD). Rates of rise and fall of the Mine Falls pool during freshets are usually gradual, normally not in excess of 0.5 feet per hour.

With this plan for hydropower development, generating flows would range from a low of about 165 cfs to a high of 660 cfs. The facility would be operated as a run-of-the-river project and when the natural river flows were less than about 205 cfs, generation would likely cease, which would be expected at least 30 percent of the time. Similarly river flows in excess of 700 cfs would be spilled, which could be as much as 32 percent of the time. The hydropower operation would have little effect on the normal seasonal fluctuation in the head pool. Fluctuations in the head pool level, as a result of a run-of-the-river hydropower operation, would be caused by the variations in loading on the plant. The head pool has a surface area of about 170 to 190 acres and the maximum change in pool level as a result of the plant going from no load to full load would be in order of 1.3 feet and could occur over a period of not less than 3 hours. At no time would the pool normally be drawn below spillway crest for purposes of power generation. However, if during low flow periods the project were being used as "spinning reserve" and an emergency need for power developed and the project were "called on line", then it is conceivable that under such an emergency, the pool would be drawn below spillway crest for a short period of time. Again, the maximum rate of such drawdown would not exceed 0.3 feet per hour.

TABLE 7

MINE FALLS
DAMSITE DEVELOPMENT (Alternative B)
TURBINE COMPARISONS

| <u>Unit Size</u> (mm) | <u>Average Head</u> (feet) | <u>Hydraulic Capacity Range</u> (cfs) | <u>Plant Factor</u> | <u>Annual Energy Potential</u> (kwh) |
|--------------------------|-------------------------------|--|-------------------------|---|
| 1,750 | 26.5 | 305/610 | 0.49 | 4,738,000 |
| 2,000 | 26.5 | 388/775 | 0.42 | 5,114,000 |
| <u>1,250/1,250</u> | <u>26.5</u> | <u>165/660</u> | <u>0.53</u> | <u>5,540,000</u> (recommended) |
| 1,500/1,500 | 26.5 | 230/920 | 0.43 | 6,265,000 |
| 1,750/1,750 | 26.5 | 305/1,220 | 0.36 | 6,946,000 |

10.3 Mine Falls Canal System Development (Alternative F)

The Mine Falls canal system originates at a gate house located just to the right of the Mine Falls Dam. The hydraulic head differential through this gate house is approximately 7.0 feet, with flows dropping from the Mine Falls head pool at approximate elevation 156 NGVD to elevation 148.9 NGVD, the present normal water level of the canal. Upon inspection, it is not obvious why the system was built with such a high head differential at the entrance, since the downstream canal dikes do not appear to have been built to permit utilizing the full head pool potential. Because of this head differential at the entrance, there exists a possibility of downstream dike failure in the event of gate misoperation or failure at the gate house, which contains five 6 ft. by 9 ft. wooden gates. For this reason, three of the gate passages have been permanently blocked and the remaining two reduced to 1/3 their original opening size, by the placement of concrete bulkheads in front of the gate passages. These presently restricted openings in front of the two remaining operational gates, limit the maximum discharge through the gate house to about 800 cfs under flood conditions and to about 450 cfs under normal conditions. Presently, flows through the gate house are regulated at about 40 cfs.

From the gate house, flows enter a Mill Pond, about 20 to 25 acres in size, before entering the narrower canal which continues along the right side of the river for some 2.5 miles. This Mill Pond has two overflow spillways discharging back to the Nashua River, with spillway lengths of 19.4 and 24 feet, which are both stoplogged controlled at a present crest elevation of about 148.4 feet NGVD. Presently, the only other outflow from the canal system is at the far end of the canal. The original main head race has been filled for a parking lot, but a stoplog controlled overflow weir with total crest length of 28 feet, at a present elevation of about 148.4 feet NGVD, has been installed which discharges a minimum flow into a remaining conduit leading through the original factory complex to the Nashua River.

Flows through the gate house into the canal system are presently in the order of 40 cfs. After some discharge over the two spillways, the remaining flow passing the length of the canal is probably not greater than 15 to 20 cfs. Therefore, present flow velocities in the canal are practically zero.

Various alternate plans of hydro development between the canal and the Nashua River were considered. No one alternate appeared obviously superior to the others; however, Alternative F was selected for which to provide further information. It is noted that any of the alternates on the canal system would require rebuilding the existing archaic gate house and equipping it with automatic and/or

remotely operated gates to permit maintaining the canal system relatively constant with varying hydropower loading. New gates providing effective cross-sectional area of 70 to 100 square feet would probably be required. With Alternative F, the power facility would be located on the canal approximately one mile below the gate house and about 3200 feet below the Mill Pond. It would be sited where the canal is relatively close to the Nashua River (\pm 300 feet) with undeveloped intervening area. Assuming the canal level can be raised one foot to 149.9 ft. NGVD, approximately 32 feet of hydraulic head would be realized at the site between the canal level and the Nashua River tailwater at 117.9 ft. NGVD. The plan would require clearing, refurbishing and stabilizing approximately 5300 ft. of the existing rather neglected canal. The costs for the canal work are quite uncertain. Detailed explorations and engineering investigations of the canal system were beyond the scope of this study but would have to be a part of any final design.

The minimum canal cross-sectional area is an estimated 200 square feet and the maximum flow capacity for hydro development was considered limited by the canal to about 600 cfs, which would result in an average velocity of about 3 ft. per second.

The recommended installation for the Alternative F plan of development on the canal would consist of twin 1250 mm, variable blade, tube type turbines, each capable of discharging 315 cfs at maximum blade angle under a head of 32.0 feet. The units would be equipped with synchronous generators with not less than 680 kw capacity each. The total hydraulic capacity would therefore be 630 cfs at a head of 32.0 feet capable of generating 1360 kw of power. The potential average annual "energy" production of the plan would be 7,222,000 kwh, at a 0.61 plant factor. Pertinent data on this plan is listed in Table 8. The twin 1250 mm units were recommended after a cursory analysis of both single and two unit installations of varying size. For reasons previously discussed, it was considered advantageous to have a facility with twin units. A comparative analysis of twin 1250, 1500 and 1750 mm units indicated that, of the three capacities, the recommended installed capacity provided by the twin 1250 mm units was the most economically feasible, based on current costs and energy values. Also, installations greater than the twin 1250 mm units are not considered advisable due to the limiting hydraulic capacity of the canal system. Pertinent information for a range of unit sizes and combinations is summarized in Table 9. Typical flow duration analysis are illustrated on Figures B-6 through B-8 (Appendix B).

The present regulated discharge through the canal system is about 40 cfs with little variation. Similarly, there is very little fluctuation in the water level of the canal system. Any fluctuation due to changes in flow is largely due to local storm runoff into the canal system from intervening drainage area, which would appear to have produced little fluctuation. The level of the canal can be

TABLE 8

MINE FALLS
CANAL SYSTEM DEVELOPMENT (Alternative F)
PERTINENT DATA

| | |
|---|---------------------------|
| 1. Number of Units | 2 |
| 2. Size of Units (mm) | 1250 |
| 3. Hydraulic Head (ft) | 32.0 |
| 4. Hydraulic Capacity per Unit (cfs) | 315 |
| 5. Total Hydraulic Capacity (cfs) | 630 |
| 6. Generator Type | Synchronous |
| 7. Generator Capacity | 680 kw each-1360 kw total |
| 8. Potential Annual Generation | 7,222,000 kwh |
| 9. Plant Factor | 0.61 |
| 10. Gate Invert (NGVD) | 141.0 |
| 11. Emergency Spillways Crest Elevations (NGVD) | 148.9-149.9 |
| 12. Canal Pool (acres) | 40-50 |
| 13. Seasonal Variations in Canal Pool Elevation | Negligible |
| 14. Maximum Pool Variations Due to Generation | Negligible |

TABLE 9

MINE FALLS
CANAL SYSTEM DEVELOPMENT (Alternative F)
TURBINE COMPARISONS

| <u>Unit Size</u> (mm) | <u>Average Head</u> (feet) | <u>Hydraulic Capacity Range</u> (cfs) | <u>Plant Factor</u> | <u>Annual Energy Potential</u> (kwh) |
|--------------------------|-------------------------------|--|-------------------------|---|
| 1,750 | 32 | 280/560 | 0.56 | 5,908,000 |
| 750/1,500 | 32 | 60/565 | 0.64 | 6,824,000 |
| 750/1,750 | 32 | 60/685 | 0.58 | 7,521,000 |
| 1,000/1,250 | 32 | 105/525 | 0.67 | 6,660,000 |
| 1,000/1,500 | 32 | 105/650 | 0.61 | 7,520,000 |
| <u>1,250/1,250</u> | <u>32</u> | <u>160/630</u> | <u>0.61</u> | <u>7,222,000</u> |
| 1,500/1,500 | 32 | 218/870 | 0.49 | 8,077,000 |
| 1,750/1,750 | 32 | 280/1,120 | 0.41 | 8,649,000 |

varied by adjustment of stoplog settings at the spillways, but this is not a common practice. The present spillways were designed to pass an emergency discharge of about 600 cfs with a rise in canal level of about 2.5 feet.

The development of hydropower on the canal would require the rebuilding of the existing gate house and equipping it with automatic and/or remotely operated gates to permit maintaining levels in the canal relatively constant while varying the flow through the gate house from a low of about 40 cfs to the maximum of 630 cfs for hydropower. This maximum discharge will require cross-sectional gate area of 70 to 100 square feet at the gate house. It is considered important that the level of the canal system be maintained relatively constant since frequent fluctuations could cause sloughing of the canal banks and dikes.

In the event the hydropower facility was generating near capacity with a flow of about 600 cfs, and the plant was taken off load and the gates in the gate house failed to operate, then the canal level would rise about 2.5 feet at which time the two spillways would discharge the 600 cfs. The canal system, including the Mill Pond, has a total surface area of about 40 to 50 acres. Therefore, under the above circumstances, the pool would rise at a rate of not greater than 1.0 ft. per hour. Under normal nonemergency operating conditions, the hydropower flows through the canal would be closely regulated at the gate house maintaining a relative constant canal level with varying hydropower loading. Generating flows would range from a low of about 160 cfs to a high of 630 cfs. The project would be operated as a run-of-river project and when the natural river flows were less than 160 cfs generation would likely cease, which would be expected at least 20% of the time. Similarly, river flows in excess of 630 cfs would not be diverted into the canal but passed down the river, which could be as much as 35% of the time. It would be expected that the river level at the canal entrance would be maintained at or near the level of the dam spillway crest (elevation 154.9 NGVD).

11.0 POWERHOUSE CHARACTERISTICS AND COSTS

11.1 Powerhouse Descriptions

Although only one plan of hydroelectric development at Mine Falls is possible, information for both the Damsite Development (Alternative B) and the Canal System Development (Alternative F) are presented for comparison.

The Mine Falls Damsite Development (Alternative B) would locate a new powerhouse approximately 500 feet downstream from the dam along the southern bank of the river. An exposed penstock would extend from the south abutment of the dam along the river edge to the powerhouse. The intake would include a concrete-lined intake channel and gatehouse. The penstock leading from the intake would be 9 feet in diameter and would be above grade and supported on concrete cradles. A general plan is shown as Plate 5 in Appendix F. The powerhouse would contain two horizontal shaft propeller turbines with runners of 1250-mm diameter, each capable of passing 330 cfs through an average head of 26.5 feet. The installed capacity is 1180 kw, and the average annual energy generation is estimated to be 5,540,000 kwh. The plant would be operated as an automatic run-of-river installation with no manned control room. (See Figure 3).

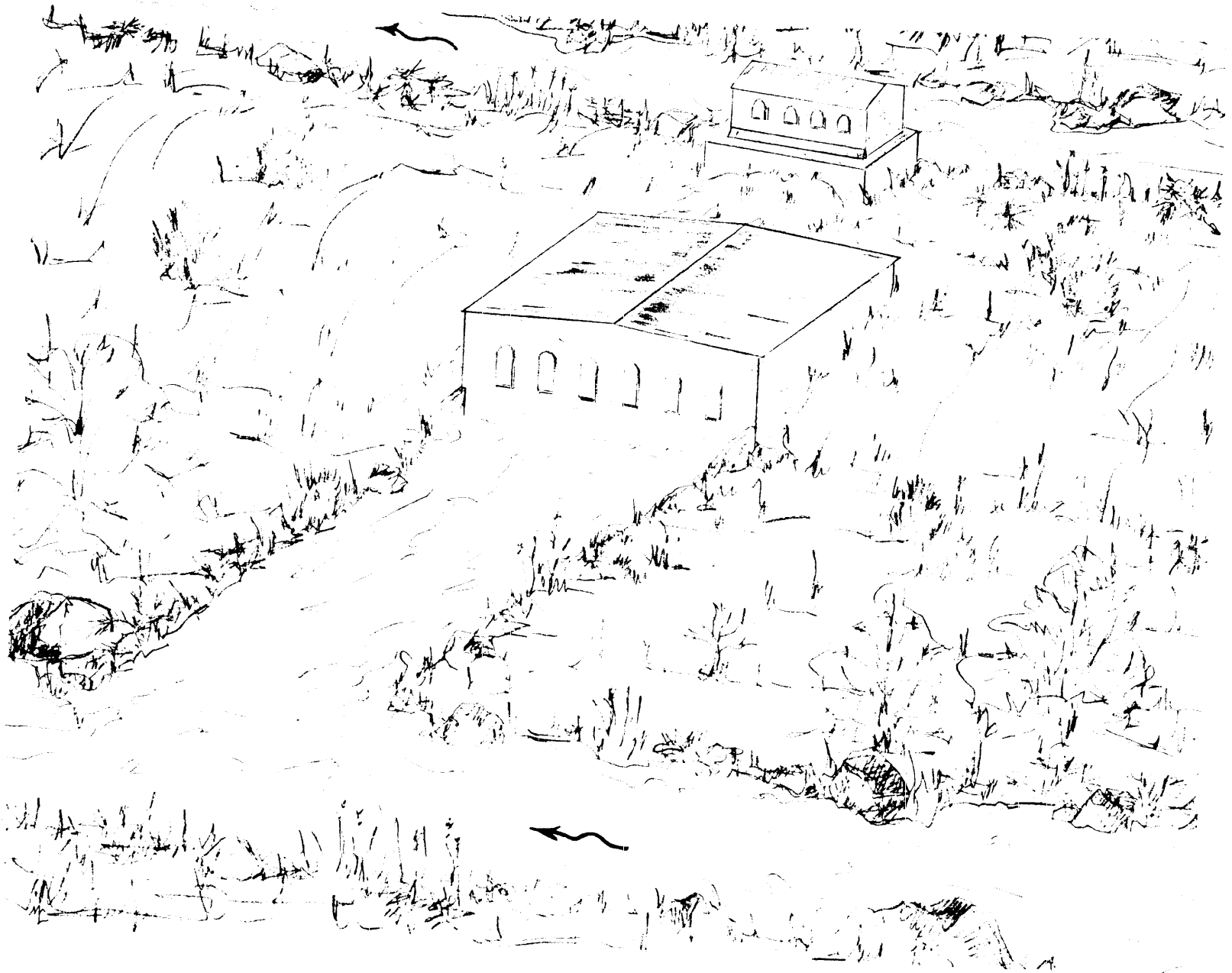
The Mine Falls Canal Development (Alternative F) would locate a new powerhouse along the canal about one mile downstream from the dam. An intake would be required through the dike of the canal and would transmit the flow through a short length of penstock to the powerhouse. After passing through the turbines, the water would be discharged to the river through a tailrace channel. The intake would include a gatehouse with concrete training walls at the entrance to match the dike configuration. A general plan is shown as Plate 6 in Appendix F. The canal would have to be desilted and restored from the millpond to the intake. The dike down to the powerhouse would require remedial work to insure its integrity. Extensive renovation would also be required of the existing gatehouse at the head of the canal system. The powerhouse would contain two horizontal shaft propeller turbines with runners of 1250-mm diameter, each capable of passing 315 cfs through an average head of 32 feet. The installed capacity is 1360 kw, and the average annual energy generation is estimated to be 7,222,000 kwh. The plant would be operated as an automatic run-of-river installation with no manned control room. (See Figure 4).

11.2 Construction Methods and Materials

Powerhouse foundations would be mass concrete on adequate bearing. The operating floor and walls would be cast-in-place concrete. Brick or appropriate facade material would be used to maintain the aesthetic quality of the surroundings. The intake gatehouses would



MINE FALLS
DAM SITE DEVELOPMENT



MINE FALLS - CANAL DEVELOPMENT

be cast-in-place concrete and would be covered to allow for indoor cleaning of trash racks and manual operation of gates. Trash racks would be standard steel bar racks inclined for ease of cleaning. The penstocks and draft tubes would be made of milled rolled steel welded together on the site. The transmission lines would be of the 4.16 kv class for transmission of power to a substation of the Public Service Company of New Hampshire.

11.3 Construction Schedules

A construction schedule for the Damsite Development (Alternative B) is shown on Figure 5 while the Canal System Development (Alternative F) is shown on Figure 6. A period of six to eighteen months would precede the beginning of any construction or ordering of equipment once a decision to construct the project has been made. This period would be necessary to secure a FERC license to operate the power station. The construction period would begin in July, since the late summer would be ideal for dewatering the site because of reduced summer flows. Once the construction began, work would be continuous except during the coldest winter months. The project should be on line 24 months after the start of construction.

11.4 Capital Costs

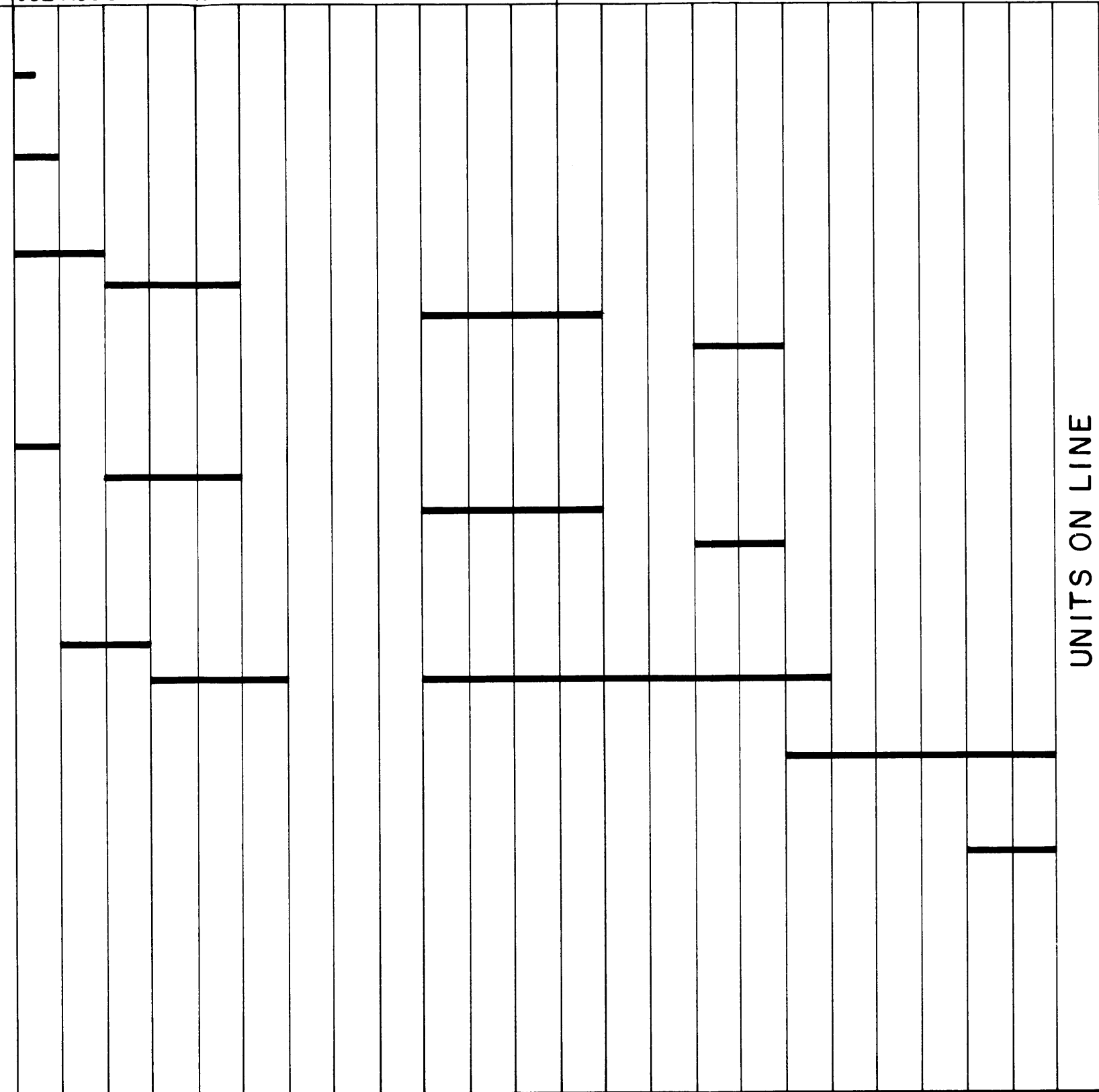
The capital cost for the Mine Falls Damsite Development (Alternative B) has been estimated to be \$2.26 million, and a breakdown appears in Table 10. The capital cost for the Mine Falls Canal System Development (Alternative F) has been estimated to be \$3.98 million, and a breakdown appears in Table 11.

Turbine cost estimates were based on Volume V of the Corps of Engineers Hydrologic Engineering Center Guide Manual dated July 1979, adjusted from July 1978 price level to July 1979 and from conversations with regional representatives of Allis-Chalmers Corp.

CONSTRUCTION SCHEDULE

SECOND YEAR

JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN



UNITS ON LINE

FINAL INSPECTION & APPROVAL CONTRACT COMPLETION

MINE FALLS DAM
ALTERNATE "F"

CONSTRUCTION SCHEDULE

| FIRST YEAR | | | | | | | | | | | | SECOND YEAR | | | | | | | | | | | |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN |

- 1. ORDER MECHANICAL & ELECTRICAL EQUIPMENT
- 2. MOBILIZATION
- 3. NASHUA CANAL
DEWATER
REMOVE SILT & WATERPROOF
REHABILITATE DIKE
- 4. MILL POND
COFFERDAM
RECONSTRUCT GATE OPENINGS
INSTALL GATES & MECHANISMS
REHABILITATE EXIST. SUPERSTRUCTURE
- 5. INTAKE STRUCTURE
EXCAVATION
SUBSTRUCTURE
SUPERSTRUCTURE
- 6. PENSTOCK
EXCAVATION
INSTALLATION
- 7. POWERPLANT
EXCAVATION
SUBSTRUCTURE
SUPERSTRUCTURE
- 8. TAIL RACE
DIVERSION
EXCAVATION & CONSTRUCTION
- 9. INSTALL MECHANICAL & ELECTRICAL EQUIPMENT
- 10. DEMOBILIZATION & AESTHETIC REHABILITATION

UNITS ON LINE
FINAL INSPECTION & APPROVAL
CONTRACT COMPLETION

TABLE 10
CAPITAL COSTS
MINE FALLS DAM
DAMSITE DEVELOPMENT (Alternative B)

| | (\$ in 1,000's) |
|---|-----------------|
| <u>Intake Structure and Channel</u> | |
| Diversion and care of water | 65 |
| Excavation and foundation preparation | 100 |
| Substructure | 110 |
| Superstructure/Building | 50 |
| Trash racks | 40 |
| Gates | 40 |
| Stoplogs | 10 |
| Subtotal | 415 |
| <u>Penstock</u> | 280 |
| <u>Powerplant Structure and Improvements</u> | |
| Clearing and access road | 65 |
| Diversion and care of water | 30 |
| Excavation and foundation | 80 |
| Substructure | 140 |
| Superstructure/Building | 100 |
| Draft tube gates | 20 |
| Subtotal | 435 |
| <u>Generating Plant and Equipment</u> | |
| Turbine/generator package | 800 |
| Transmission and substation costs | 80 |
| Subtotal | 880 |
| TOTAL DIRECT COSTS | 2,010 |
| <u>Engineering and Construction Supervision</u> | 250 |
| TOTAL CAPITAL COST | 2,260 |

TABLE 11
CAPITAL COSTS
MINE FALLS DAM
CANAL SYSTEM DEVELOPMENT (Alternative F)

| <u>Intake/Gatehouse</u> | (\$ in 1,000's) |
|---|-----------------|
| Diversion and care of water | 20 |
| Excavation and foundation preparation | 20 |
| Substructure | 60 |
| Superstructure/Building | 30 |
| Trash Racks | 40 |
| Gates | 40 |
| Stoplogs | 10 |
| Subtotal | 220 |
| <u>Powerplant Structure and Improvements</u> | |
| Clearing and access road | 60 |
| Diversion and care of water | 20 |
| Excavation and foundation preparation | 40 |
| Substructure | 160 |
| Superstructure/Building | 90 |
| Penstock | 30 |
| Draft tube gates | 20 |
| Subtotal | 420 |
| <u>Tailrace</u> | 60 |
| <u>Mine Falls Pond Gate Renovation</u> | 800 |
| <u>Canal Desilting and Waterproofing</u> | 400 |
| <u>Rehabilitate Dike</u> | 800 |
| <u>Generating Plant and Equipment</u> | |
| Turbine/generator package | 800 |
| Transmission and substation costs | 80 |
| Subtotal | 880 |
| TOTAL DIRECT COSTS | 3,580 |
| <u>Engineering and Construction Supervision</u> | 400 |
| TOTAL CAPITAL COST | 3,980 |

12.0 FINANCIAL ANALYSIS

The financial scenario developed for hydroelectric generation at Mine Falls assumed that the City of Nashua would provide funding through 20-year bonds bearing an interest rate of 6%, serviced with a sinking fund established for the life of the bond issue.

The benefits are derived from the sale of the total power produced at the generating facility to the grid system. An order by the Public Utilities Commission of New Hampshire set a rate of 4¢/KWH to be paid for the output of run-of-river plants such as the proposed project at Mine Falls. (Reference 9).

The costs include the capital cost of the plant and operation and maintenance which has been assumed to be two percent annually of the Total Direct Cost shown in Tables 10 and 11.

Hydropower generating equipment typically has a service life of 50 years, providing that it is well maintained. The equipment selected for this study has been designed for standard application, a concept which has only been on the market for a few years. Therefore, a conservative life span of 40 years was assumed.

Since interest rates fluctuate, a sensitivity analysis was performed using interest rates of 4 percent, 6 percent, 8 percent and 10 percent. Table 12 presents a summary of the financial analysis of the various interest rates. The analysis compares present worth revenues (benefits) from the sale of power to present worth costs. The following pages show backup calculations and a cash flow with amortization of Capital Cost.

It is seen that hydroelectric power at Mine Falls should be developed at the damsite (Alternative B). Although the project would be operated at a deficit for the first years as shown in the cash flow, revenue in the latter years more than makes up for this. It is also noted that revenue was derived using a rate of 4¢/KWH which was set in April 1979 by the Public Utilities Commission (PUC). Hearings are presently being held by the PUC, and an increase in the rate is expected shortly.

TABLE 12

PRESENT WORTH BENEFITS AND COSTS

Mine Falls Damsite Development (Alternative B)

Project Life: 40 years
 Initial Cost: \$2,260,000
 Energy: 5,540,000 KWH
 Benefits: 4¢/KWH

| | 4% | 6% | 8% | 10% |
|------------------------|-------------|-------------|-------------|-------------|
| Present Worth Benefits | \$4,386,000 | \$3,334,000 | \$2,643,000 | \$2,167,000 |
| Present Worth Costs | 3,056,000 | 2,865,000 | 2,739,000 | 2,653,000 |
| Benefit/Cost Ratio | 1.44 | 1.16 | 0.96 | 0.82 |

Mine Falls Canal System Development (Alternative F)

Project Life: 40 years
 Initial Cost: \$3,980,000
 Energy: 7,222,000 KWH
 Benefits: 4¢/KWH

| | 4% | 6% | 8% | 10% |
|------------------------|-------------|-------------|-------------|-------------|
| Present Worth Benefits | \$5,718,000 | \$4,346,000 | \$3,445,000 | \$2,825,000 |
| Present Worth Costs | 5,397,000 | 5,057,000 | 4,834,000 | 4,680,000 |
| Benefit/Cost Ratio | 1.06 | 0.86 | 0.71 | 0.60 |

BENEFIT/COST ANALYSIS

Mine Falls Dam Site Development (Alternative B)

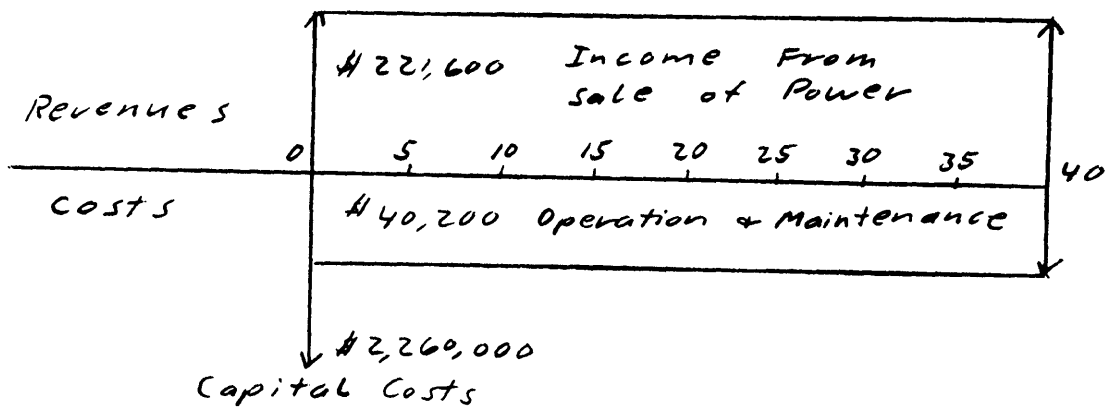
Project Life : 40 years

Initial Cost : \$2,260,000

Energy : 5,540,000 kWh

Benefits : 4¢/kWh

Interest Rate : 4%



$$\begin{aligned}
 \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$2,010,000) \\
 &= \$40,200
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (5,540,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\
 &= \$221,600/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Benefits} &= \$221,600 (P/A)_{40}^{4\%} \\
 &= \$221,600 (19.793) \\
 &= \$4,386,129
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Costs} &= \$2,260,000 + \$40,200 (P/A)_{40}^{4\%} \\
 &= \$2,260,000 + \$795,679 \\
 &= \$3,055,679
 \end{aligned}$$

$$\text{Benefits / costs} = \frac{\$4,386,129}{\$3,055,679} = \underline{\underline{1.44}}$$

BENEFIT/COST ANALYSIS

Mine Falls Dam site Development (Alternative B)

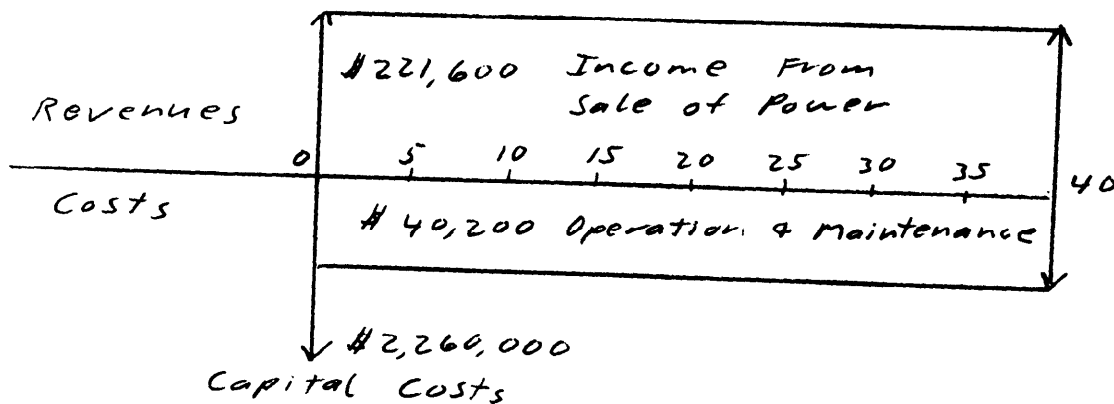
Project Life: 40 years

Initial Cost: \$2,260,000

Energy : 5,540,000 kWh

Benefits : 4¢/kWh

Interest Rate: 6%



$$\begin{aligned}
 \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$2,010,000) \\
 &= \$40,200
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (5,540,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\
 &= \$221,600/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth Benefits} &= \$221,600 (P/A)_{40}^{6\%} \\
 &= \$221,600 (15.046) \\
 &= \$3,334,194
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth Costs} &= \$2,260,000 + \$40,200 (P/A)_{40}^{6\%} \\
 &= \$2,260,000 + \$604,849 \\
 &= \$2,864,849
 \end{aligned}$$

$$\text{Benefits/Costs} = \frac{\$3,334,194}{\$2,864,848} = \underline{\underline{1.16}}$$

BENEFIT/COST ANALYSIS

Mine Falls Damsite Development (Alternative B)

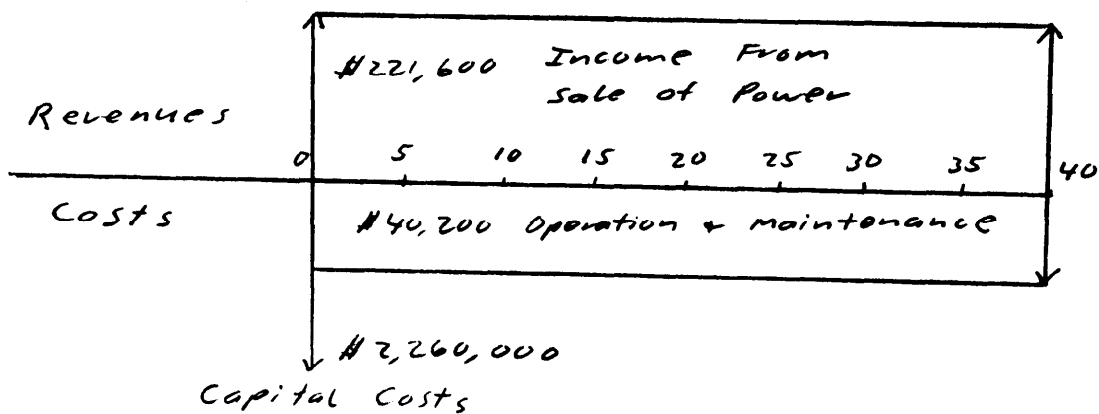
Project Life : 40 years

Initial Cost : \$2,260,000

Energy : 5,540,000 kWh

Benefits : 4¢/kWh

Interest Rate : 8%



$$\begin{aligned}
 \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$2,010,000) \\
 &= \$40,200
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (5,540,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\
 &= \$221,600/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Benefits} &= \$221,600 (P/A)_{40}^{8\%} \\
 &= \$221,600 (11.925) \\
 &= \$2,642,580
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Costs} &= \$2,260,000 + \$40,200 (P/A)_{40}^{8\%} \\
 &= \$2,260,000 + \$479,385 \\
 &= \$2,739,385
 \end{aligned}$$

$$\text{Benefits / Costs} = \frac{\$2,642,580}{\$2,739,385} = \underline{\underline{0.96}}$$

BENEFIT/COST ANALYSIS

Mine Falls Damsite Development (Alternative #3)

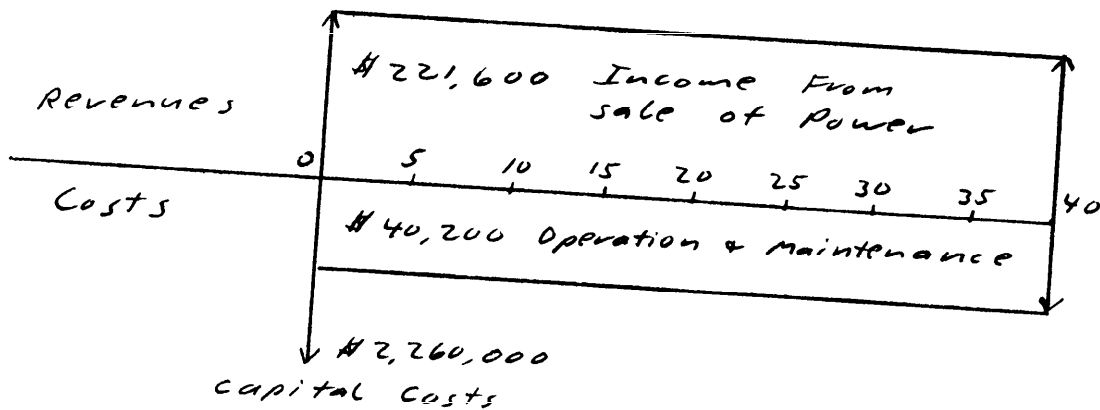
Project Life : 40 years

Initial Cost : \$2,260,000

Energy : 5,540,000 kWh

Benefits : 4¢/kWh

Interest Rate : 10%



$$\begin{aligned}
 \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$2,010,000) \\
 &= \$40,200
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (5,540,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\
 &= \$221,600/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth Benefits} &= \$221,600 (P/A)_{40}^{10\%} \\
 &= \$221,600 (9.779) \\
 &= \$2,167,026
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth costs} &= \$2,260,000 + \$40,200 (P/A)_{40}^{10\%} \\
 &= \$2,260,000 + \$393,116 \\
 &= \$2,653,116
 \end{aligned}$$

$$\text{Benefits / costs} = \frac{\$2,167,026}{\$2,653,116} = \underline{\underline{0.82}}$$

CASH FLOW WITH AMORTIZATION OF CAPITAL COST

Mine Falls Dam Site Development (Alternative B)

Project Life: 40 years

Initial Cost: \$2,260,000

Energy : 5,540,000 KWH

Benefits : 4¢ / KWH

Interest Rate: 6%

20 year Bond Life

YEARS 1-20

$$\begin{aligned}\text{Costs: Amortization} &= \$2,260,000 (A/P)_{20}^{6\%} \\ &= \$2,260,000 (.08718) = \$197,027\end{aligned}$$

$$\begin{aligned}\text{Operation \& maintenance} \\ &= .02(\$2,010,000) = \$40,200\end{aligned}$$

$$\text{Total Annual Cost} = \$237,227$$

$$\begin{aligned}\text{Revenues} \\ (5,540,000 \text{ KWH/yr}) (4¢/\text{KWH}) &= \$221,600\end{aligned}$$

$$\text{Net Cash Flow} = \$-15,627/\text{yr}$$

YEARS 21-40

Costs:

$$\begin{aligned}\text{Operation \& maintenance} \\ &= .02(\$2,010,000) = \$40,200\end{aligned}$$

Revenues:

$$(5,540,000 \text{ KWH/yr}) (4¢/\text{KWH}) = \$221,600$$

$$\text{Net Cash Flow} = \$181,400/\text{yr}$$

BENEFIT/COST ANALYSIS

mine falls Canal System Development (Alternative F)

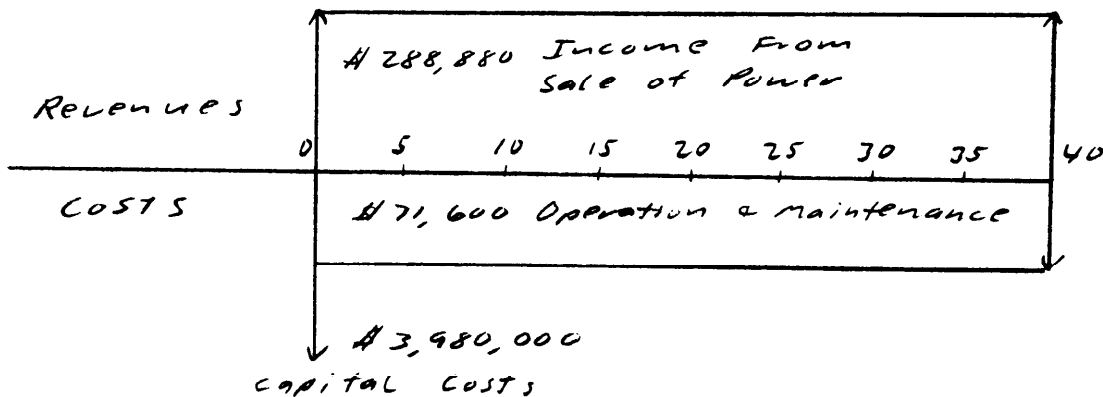
Project Life : 40 years

Initial Cost : \$3,980,000

Energy : 7,222,000 KWH

Benefits : 4¢/KWH

Interest Rate : 4%



$$\begin{aligned}
 \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$3,580,000) \\
 &= \$71,600
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (7,222,000 \text{ KWH/yr}) (4¢/\text{KWH}) \\
 &= \$288,880/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Benefits} &= \$288,880 (P/A)_{40}^{4\%} \\
 &= \$288,880 (19.793) \\
 &= \$5,717,802
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Costs} &= \$3,980,000 + \$71,600 (P/A)_{40}^{4\%} \\
 &= \$3,980,000 + \$1,417,179 \\
 &= \$5,397,179
 \end{aligned}$$

$$\text{Benefits/Costs} = \frac{\$5,717,802}{\$5,397,179} = \underline{\underline{1.06}}$$

BENEFIT/COST ANALYSIS

Mine Falls Canal System Development (Alternative F)

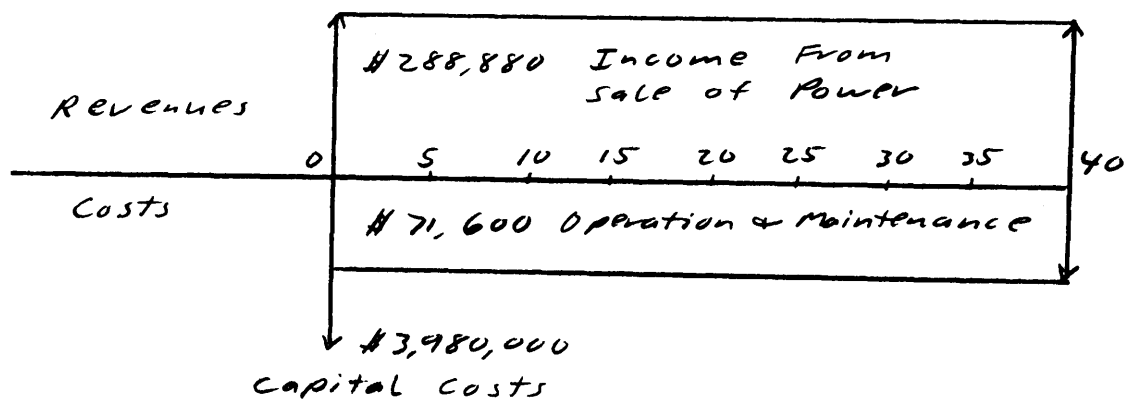
Project Life : 40 years

Initial Cost : \$3,980,000

Energy : 7,222,000 KWH

Benefits : 4¢/KWH

Interest Rate : 6%



$$\begin{aligned}
 \text{Operation \& maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$3,580,000) \\
 &= \$71,600
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (7,222,000 \text{ KWH/yr}) (4¢/\text{KWH}) \\
 &= \$288,880/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth Benefits} &= \$288,880 (P/A)_{40}^{6\%} \\
 &= \$288,880 (15.046) \\
 &= \$4,346,489
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth Costs} &= \$3,980,000 + \$71,600 (P/A)_{40}^{6\%} \\
 &= \$3,980,000 + \$1,077,294 \\
 &= \$5,057,294
 \end{aligned}$$

$$\text{Benefits / costs} = \frac{\$4,346,489}{\$5,057,294} = \underline{\underline{0.86}}$$

BENEFIT/COST ANALYSIS

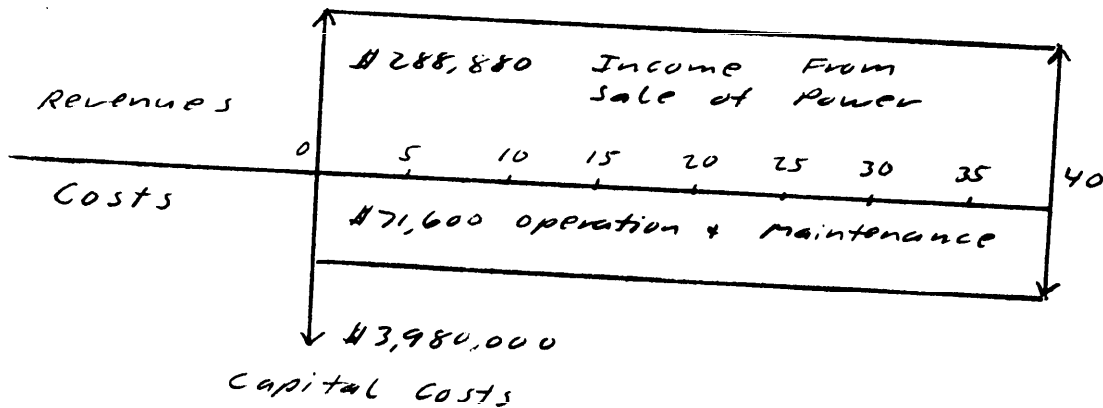
Mine Falls Canal System Development (Alternative F)
 Project Life : 40 years

Initial Cost : \$3,980,000

Energy : 7,222,000 kWh

Benefits : 4¢/kWh

Interest Rate : 8%



$$\begin{aligned} \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\ &= .02 (\$3,980,000) \\ &= \$71,600 \end{aligned}$$

$$\begin{aligned} \text{Revenues} &= (7,222,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\ &= \$288,880/\text{yr} \end{aligned}$$

$$\begin{aligned} \text{Present Worth Benefits} &= \$288,880 (P/A)_{40}^{8\%} \\ &= \$288,880 (11.925) \\ &= \$3,444,894 \end{aligned}$$

$$\begin{aligned} \text{Present Worth Costs} &= \$3,980,000 + \$71,600 (P/A)_{40}^{8\%} \\ &= \$3,980,000 + \$853,830 \\ &= \$4,833,830 \end{aligned}$$

$$\text{Benefits/costs} = \frac{\$3,444,894}{\$4,833,830} = \underline{\underline{0.71}}$$

BENEFIT/COST ANALYSIS

Mine Falls Canal system Development (Alternative F)

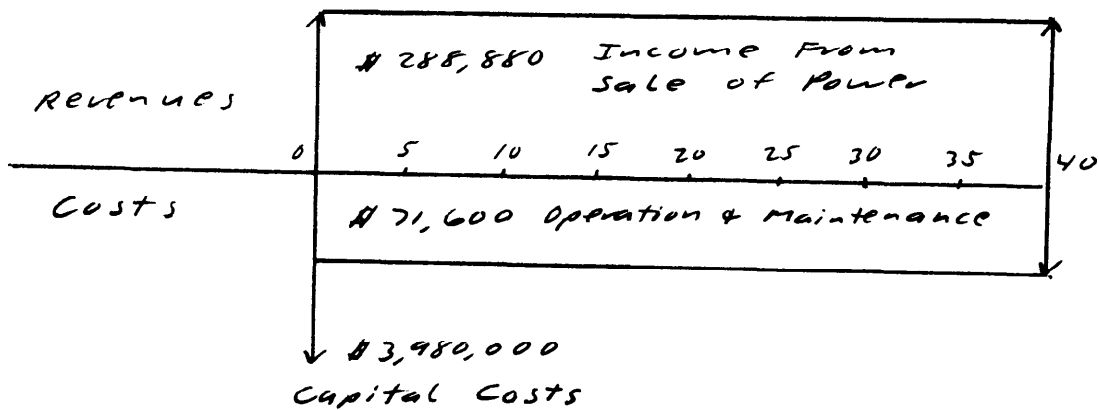
Project Life: 40 years

Initial Cost : \$3,980,000

Energy : 7,222,000 kWh

Benefits : 4¢/kWh

Interest Rate : 10%



$$\begin{aligned}
 \text{Operation \& maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$3,580,000) \\
 &= \$71,600
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (7,222,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\
 &= \$288,880/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Benefits} &= \$288,880 (P/A)_{40}^{10\%} \\
 &= \$288,880 (9.779) \\
 &= \$2,824,958
 \end{aligned}$$

$$\begin{aligned}
 \text{Present Worth Costs} &= \$3,980,000 + \$71,600 (P/A)_{40}^{10\%} \\
 &= \$3,980,000 + \$700,176 \\
 &= \$4,680,176
 \end{aligned}$$

$$\text{Benefits/Costs} = \frac{\$2,824,958}{\$4,680,176} = \underline{\underline{0.60}}$$

CASH FLOW WITH AMORTIZATION OF CAPITAL COST

Mine Falls Canal System Development (ALTERNATIVE F)

Project Life : 40 years

Initial Cost : \$3,980,000

Energy : 7,222,000 kWh

Benefits : 4¢/kWh

Interest Rate : 6%

20 year Bond Life

YEARS 1-20

$$\begin{aligned}\text{Costs: Amortization} &= \$3,980,000 (A/P)_{20}^{6\%} \\ &= \$3,980,000 (.08718) = \$346,976\end{aligned}$$

$$\begin{aligned}\text{Operation \& Maintenance} \\ &= .02(\$3,580,000) = \$71,600\end{aligned}$$

$$\text{Total Annual Cost} = \$418,576$$

Revenues

$$(7,222,000 \text{ kWh/yr}) (4¢/\text{kWh}) = \$288,880$$

$$\text{Net Cash Flow} = \$-129,696$$

YEARS 21-40

Costs:

$$\begin{aligned}\text{Operation \& Maintenance} \\ &= .02(\$3,580,000) = \$71,600\end{aligned}$$

Revenues:

$$(7,222,000 \text{ kWh/yr}) (4¢/\text{kWh}) = \$288,880$$

$$\text{Net Cash Flow} = \$217,280$$

13.0 RECOMMENDATIONS

At Mine Falls, a total of nine alternatives were considered for hydroelectric development. After assessing the impacts and engineering constraints, two plans were looked at in further detail: (1) hydroelectric development at the damsite (Alternative B) and (2) development along the canal (Alternative F).

The analysis and discussion in this report supports the recommendation that hydroelectric power at Mine Falls be developed at the damsite (Alternative B). Development at the dam appears the most practical and feasible, as it would not disturb or be associated with the operation, preservation and maintenance of an old and delicate canal system.

The recommended plan for hydroelectric development at Mine Falls (Alternative B) would locate a new powerhouse approximately 500 feet downstream from the dam along the southern bank of the river. An exposed penstock would extend from the south abutment of the dam along the river edge to the powerhouse. The intake would include a concrete-lined intake channel and gatehouse. The penstock leading from the intake would be nine feet in diameter and would be above grade and supported on concrete cradles. A general plan is shown as Plate 5 in Appendix F. The powerhouse would contain two horizontal shaft propeller turbines with runners of 1250-mm diameter, each capable of passing 330 cfs through an average head of 26.5 feet. The installed capacity is 1180 kw, and the average annual energy generation is estimated to be 5,540,000 kwh. The plant would be operated as an automatic run-of-river installation with no manned control room. Emergency shutdown mechanisms would be provided for the safety and protection of the automatic equipment. Maintenance would be limited to cleaning of trash racks and inspection of equipment. (See Figure 3, Section 11.0).

14.0 REGULATORY AND LICENSING CONSIDERATIONS

The proposed project is on the Nashua River which is currently classified as a navigable waterway. Thus, the project is under Federal Energy Regulatory Commission (FERC) jurisdiction as well as State jurisdiction. Since the project would have an installed capacity of less than 2000 HP (1500 KW), a short-form license application for a minor project with FERC can be employed. This license, a copy of which is presented in Appendix E, has incorporated a simplified procedure and format to save time and expense for the applicant.

The FERC license application requires that permits and approvals be obtained from numerous Federal, State and local authorities. At the Federal level, a dredge and fill permit must be obtained from the U.S. Army Corps of Engineers, and approval of the proposed project is necessary from the U.S. Environmental Protection Agency and the Fish and Wildlife Service of the U.S. Department of the Interior. Required at the State level are approval of the dam's safety by the Water Resources Board, a dredge and fill permit from the Special Board of the Water Resources Board, a State water quality certificate and a dredge and fill permit from the Water Supply and Pollution Control Commission, and approvals from the Fish and Game Department and the Office of Historic Preservation of the Department of Resources and Economic Development. Prior to construction, determination will have to be made if local building permits will have to be acquired.

If the environmental report section in the license application was unacceptable to a State or Federal agency, then an Environmental Impact Statement (EIS) may be required. In this case, a \$20,000 - \$100,000 expense and a minimum of a year project delay can be expected. Since the dam is existing and no major structural, hydraulic or pollution modeling or analysis is anticipated, an EIS for this project would be a lesser expenditure. FERC officials estimate the short-form licensing procedure, without the requirement of an EIS will take from 3 to 6 months for review by their agency after all State and other Federal approvals have been obtained.

Final approval and licensing of the Mine Falls project will be based upon the assessment of the probable environmental impacts and the public needs including recreational, historical and archaeological. Consideration will be made of the project's impact on land use, water quality, fish and wildlife, recreation, historic and scenic value. Final approval will depend upon the applicant's ability to demonstrate that the proposed project will not endanger the safety, health or welfare of the general public or abutting landowners and will maintain the existing natural environmental conditions.

Presented in Appendix E are two flow diagrams designed to show the procedure to follow for successfully obtaining State approval and Federal licensing for the proposed project. The darker arrows in the flow diagram indicate the expected/desired path to be followed in this proposed project to obtain the necessary approvals and FERC licensing.

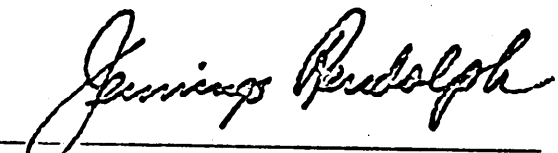
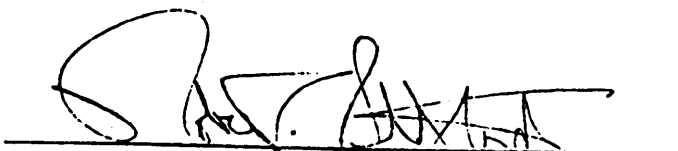
APPENDIX A - Significant Correspondence

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on the Merrimack River, Massachusetts and New Hampshire, published as House Document Number 689, 75th Congress, 3rd Session, and other reports with a view to determining whether any modification of the recommendations contained therein is advisable at the present time, with particular reference to, but not limited to, hydroelectric power development of the Jackson Mills and Mines Falls Dam projects on the Nashua River, New Hampshire.


Jennings Randolph, CHAIRMAN
Robert T. Stafford, RANKING MINORITY MEMBER

Adopted:December..6,..1978

GPO 88-717-4

(At the request of Senator John A. Durkin, New Hampshire)



STATE OF NEW HAMPSHIRE

Office of the Governor

2½ Beacon Street

Concord, NH 03301

603/271-2711

Toll Free 1-800-852-3466

Governor's Council on Energy

May 16, 1979

Mr. Joseph Ignazio
Chief, Planning Division
U.S. Army Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02154

Re: Jackson Mills and Mines Falls Dams, Nashua, New Hampshire - (W15#14035)

Dear Mr. Ignazio:

I direct your attention to the following pertinent material concerning hydro feasibility in New Hampshire.

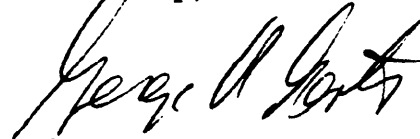
- Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire, by the Energy Law Institute, Franklin Pierce Law Center, Concord, N.H. for the US DOE, contract #ET-78-S-02-4934, 1979.
- Fundamental Economic Issues in the Development of Small Scale Hydro, same author and contract.
- Report of the New Hampshire PUC on DE-78-232 and DE 78-233 concerning Rates for Sale of Power by Limited Electrical Energy Producers.

This last document is very important, as it establishes the rate for small (under 5MW) power producers under a state law of 1978. Until the regulations under PURPA Title II (the National Energy Act of 1978) are promulgated and the PUC reviews this rate, small hydro producers selling all of their power to the utility will receive 4.5¢ per kwhr for firm capacity and 4.0¢ per kwhr for non-firm capacity.

A piece of legislation is being considered this year in New Hampshire which would also give small power producers the right to have power wheeled by a utility to an ultimate customer. The legislation is receiving a favorable response, and could have substantial implications for the two sites in Nashua.

I look forward to the Pre-Reconnaissance Report in June. If I can be of further assistance, please contact me.

Sincerely,



George R. Gantz
Director of Research
and
Policy Analysis

cc:
Mr. Alex Grier
Anderson-Nichols, Co.
150 Causeway St.
Boston, MA 02114

GRG/lb



NEW HAMPSHIRE DEPARTMENT of RESOURCES and ECONOMIC DEVELOPMENT

GEORGE GILMAN
COMMISSIONER

TELEPHONE 603 271-2411

November 29, 1979

Joseph L. Ignazio
Chief, Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Attention: Gard D. Blodgett

Dear Mr. Ignazio:

In accordance with 36 CFR 800, the New Hampshire State Historic Preservation Office has reviewed the proposed development of a small hydropower project at Mine Falls Dam in Nashua, New Hampshire.

The New Hampshire State Historic Preservation Office concurs with the Corps of Engineers' recommendation for further testing of areas in proximity to known and anticipated prehistoric and historic sites, as described in the report forwarded with your letter of October 10, 1979.

We look forward to receiving the completed cultural resource studies for review and comment.

Sincerely,

George Gilman, Commissioner
Dept. of Resources & Economic Development
NH State Historic Preservation Officer

GG:g

cc: Sharon Conway, ACHP
Nashua Reg. Plng. Comm.
Gary W. Hume, SHPO Archaeologist



LISTING OF CONTACT/COORDINATION
DURING REPORT PREPARATION

| AGENCY | INDIVIDUAL OR OFFICE CONTACTED | PURPOSE OF CONVERSATION/MEETING |
|---|--|---|
| Allis-Chalmers | John LaFlamme | Turbine units |
| Baker Library (Harvard University, Cambridge, MA) | Robert Lovett | Engineering records of canal |
| Bofors-Nohab | | Turbine units |
| City of Nashua | Mayor's office Tax Assessor Planning Board | Tax map data and planning information |
| Environmental Law Institute (Franklin Pierce Law Center, Concord, NH) | Peter Brown | Regulatory aspects of proposed project |
| Hamilton Engineering (Nashua, NH) | David Farr | Engineering report on Mine Falls Park |
| James River-Pepperell Company (East Pepperell, MA) | Edmond Roux | Operating procedures of hydropower unit and flow maintenance upstream on Nashua River |
| Merrimack Valley Textile Museum (No. Andover, MA) | Angela Wright | Historical and engineering background on canal |
| Nissho-Iwai American Corp. | | Turbine units |
| Nissitissit River Trust | Jeffrey Smith | Nissitissit River hydrology |
| Public Service Company of New Hampshire | John Lyons | Sale of power |
| Society of Industrial Archaeology (Elliot, ME) | Richard Candee | Canal history and data |
| State of Massachusetts Water Pollution Control | Han Bonne | Flow Maintenance at James River-Pepperell Company |

| | | |
|--|---|---|
| State of New Hampshire Dept. of Fish and Game | Stephen Virgin | Regulatory aspects |
| Dept. of Resources and Economic Development | Gary Hume Joseph Quinn Linda Wilson | Archaeological poten- tial, regulatory aspects and historical signifi- cance relating to proposed project |
| Governor's Council on Energy | George Gantz William Humm | Regulatory aspects and marketing |
| Office of Secretary of State | | NH Legislation on Small-Scale Hydro |
| Public Utilities Commission | Bruce Ellsworth | Rate information |
| Water Pollution Con- trol Commission | Walter Carlson Donald Cheseborough | Nashua River water quality and state permits |
| Water Resources Board | Gary Kerr Vernon Knowlton | Dam safety and state permits from WRB |
| Sulzer Brothers, Inc. | | Turbine units |
| Tampella-Madden Corp. | | Turbine units |
| United States Federal Energy Regulatory Commission | Edward Abrams Ronald Corso | Regulatory aspects and licensing requirements |
| Geological Survey | William McDonough William Wandle | Nashua River hydrology |

APPENDIX B - Flow Duration Analysis

NASHUA RIVER HYDROLOGY

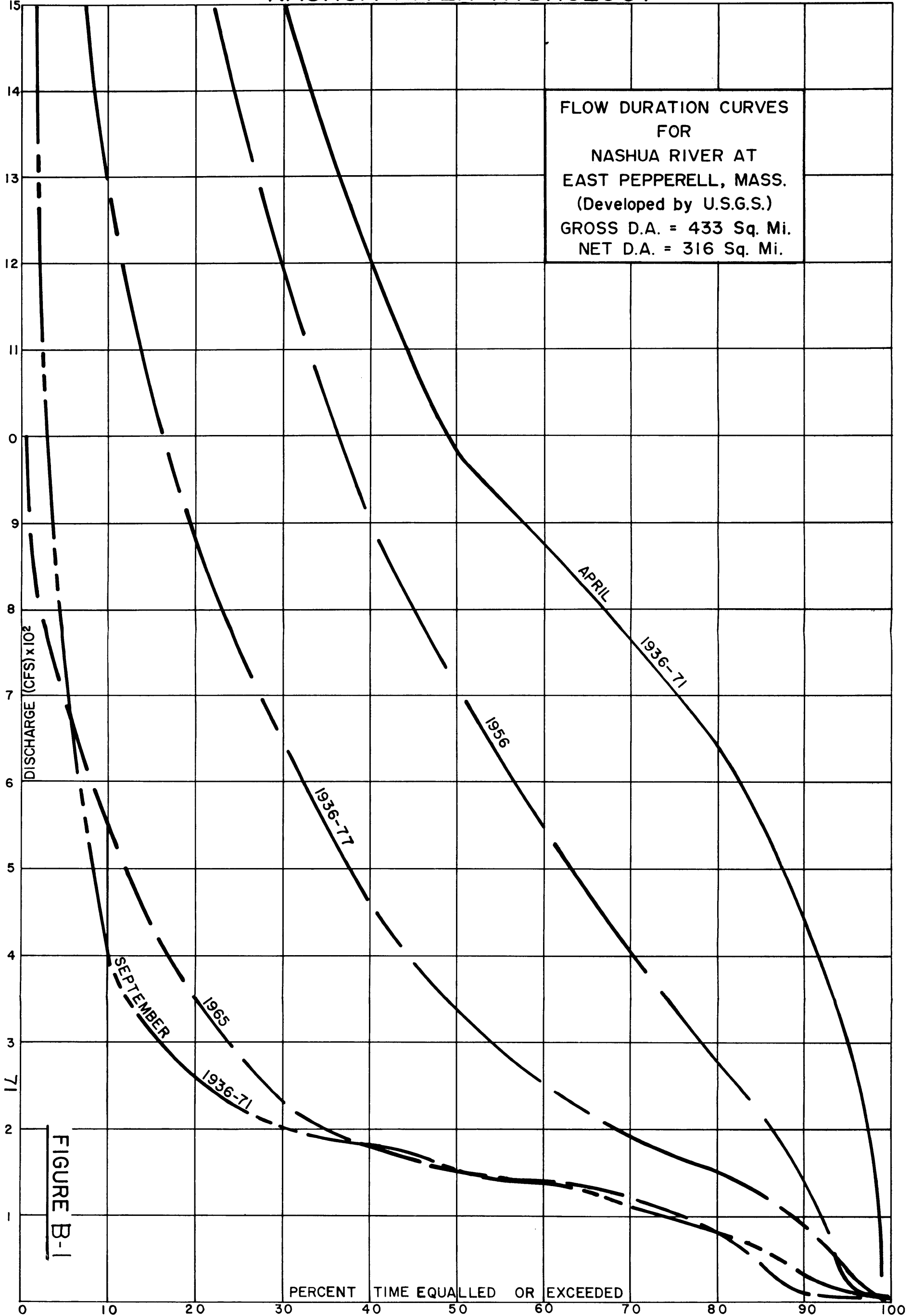
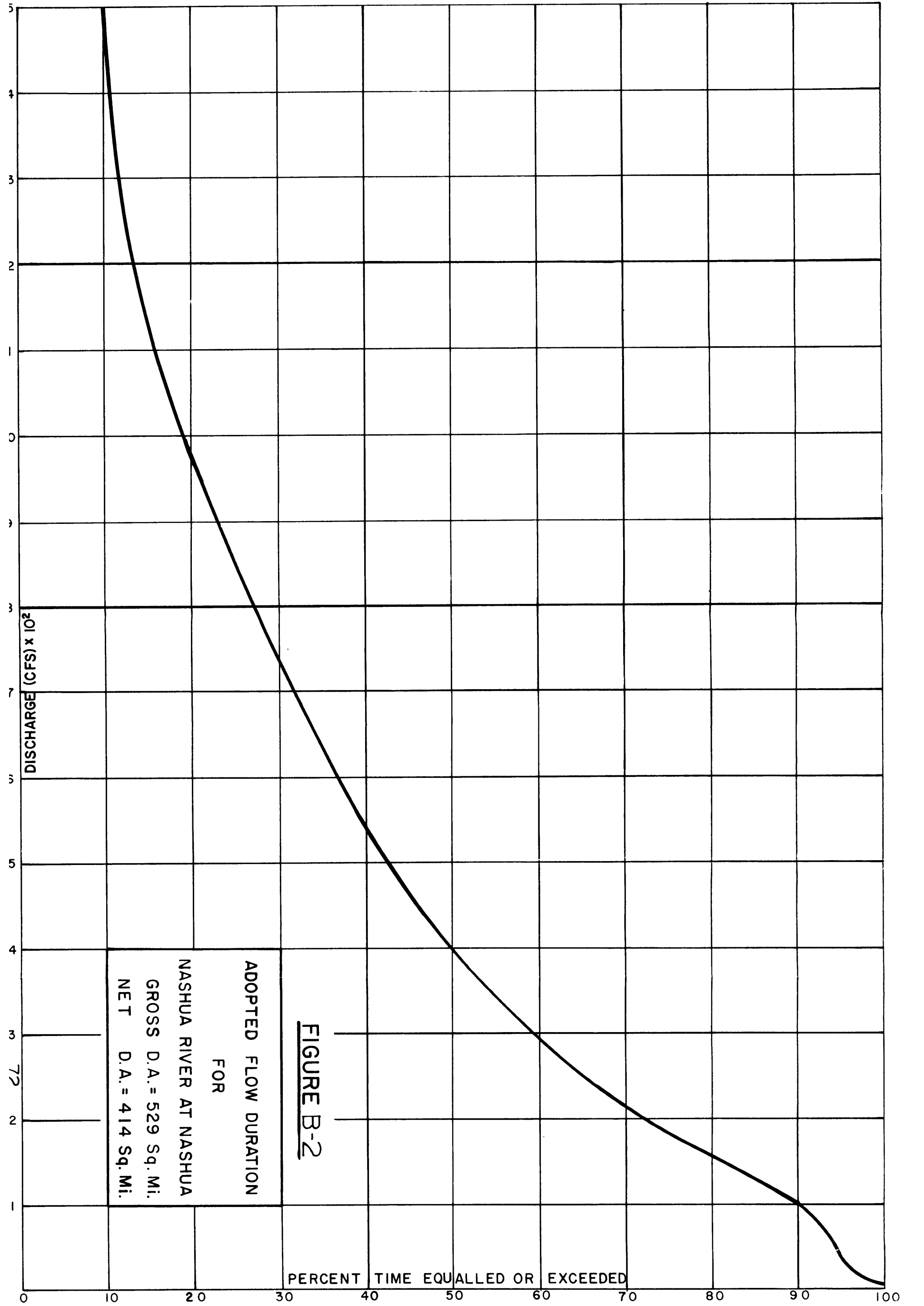
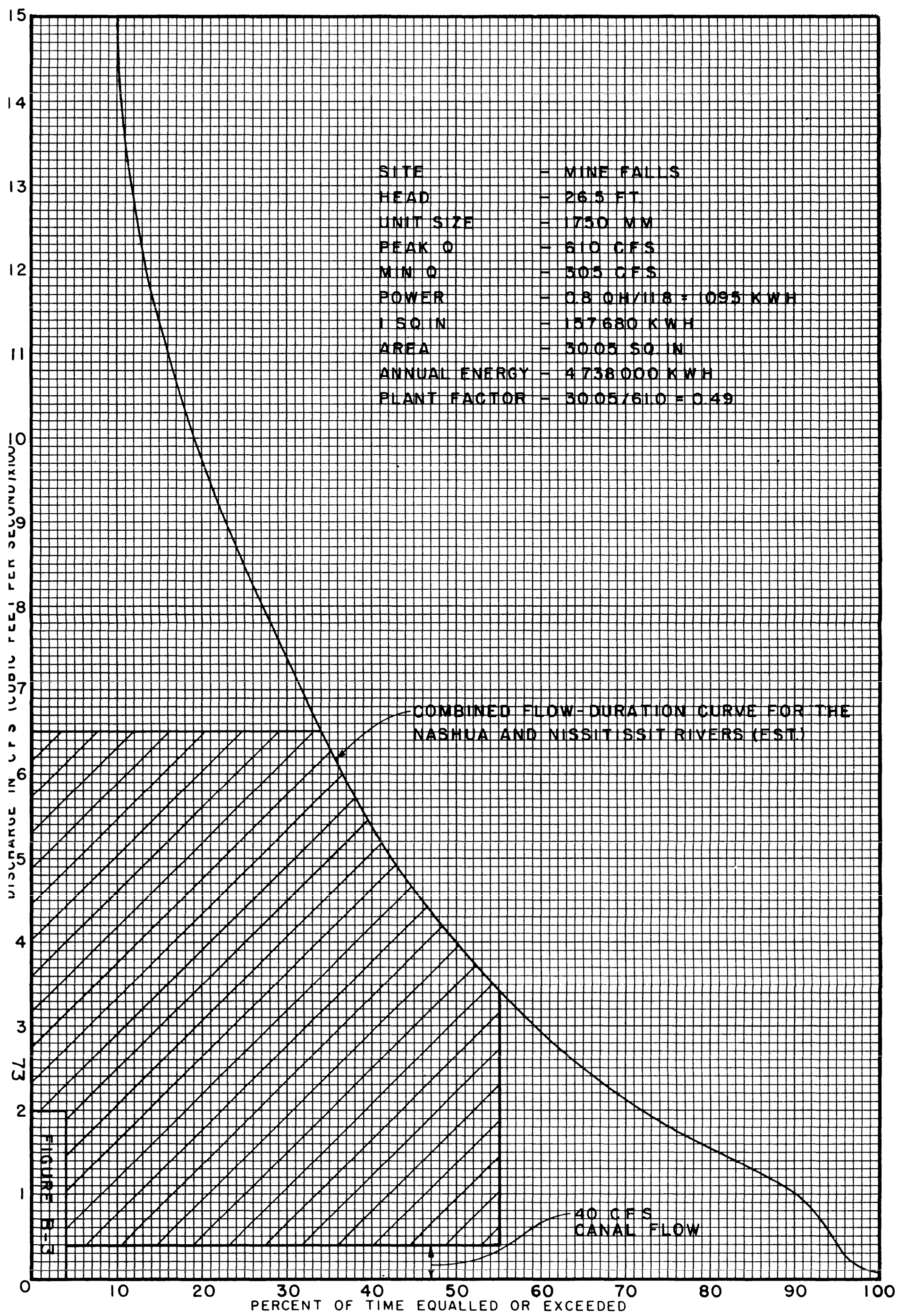
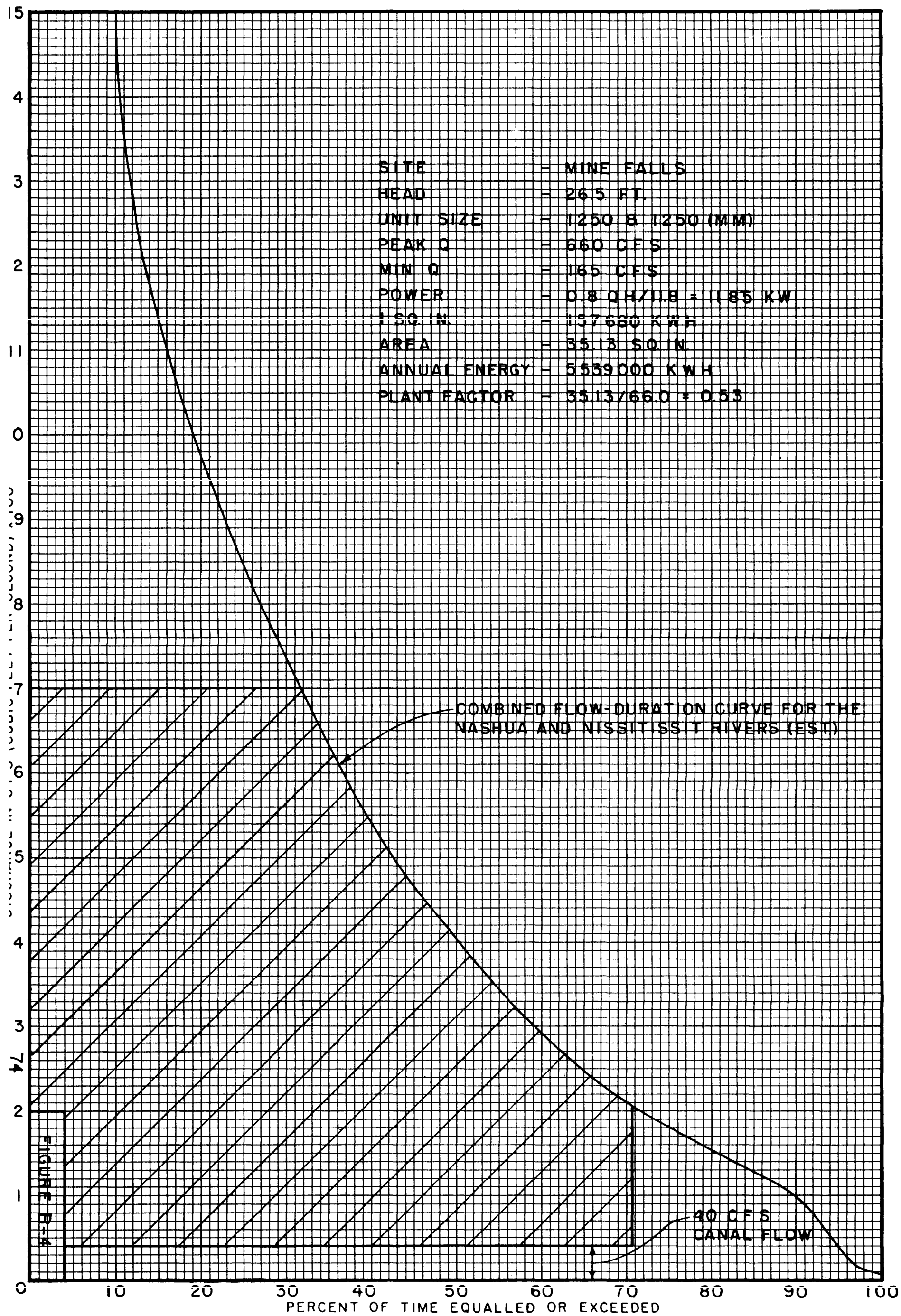


FIGURE B-1

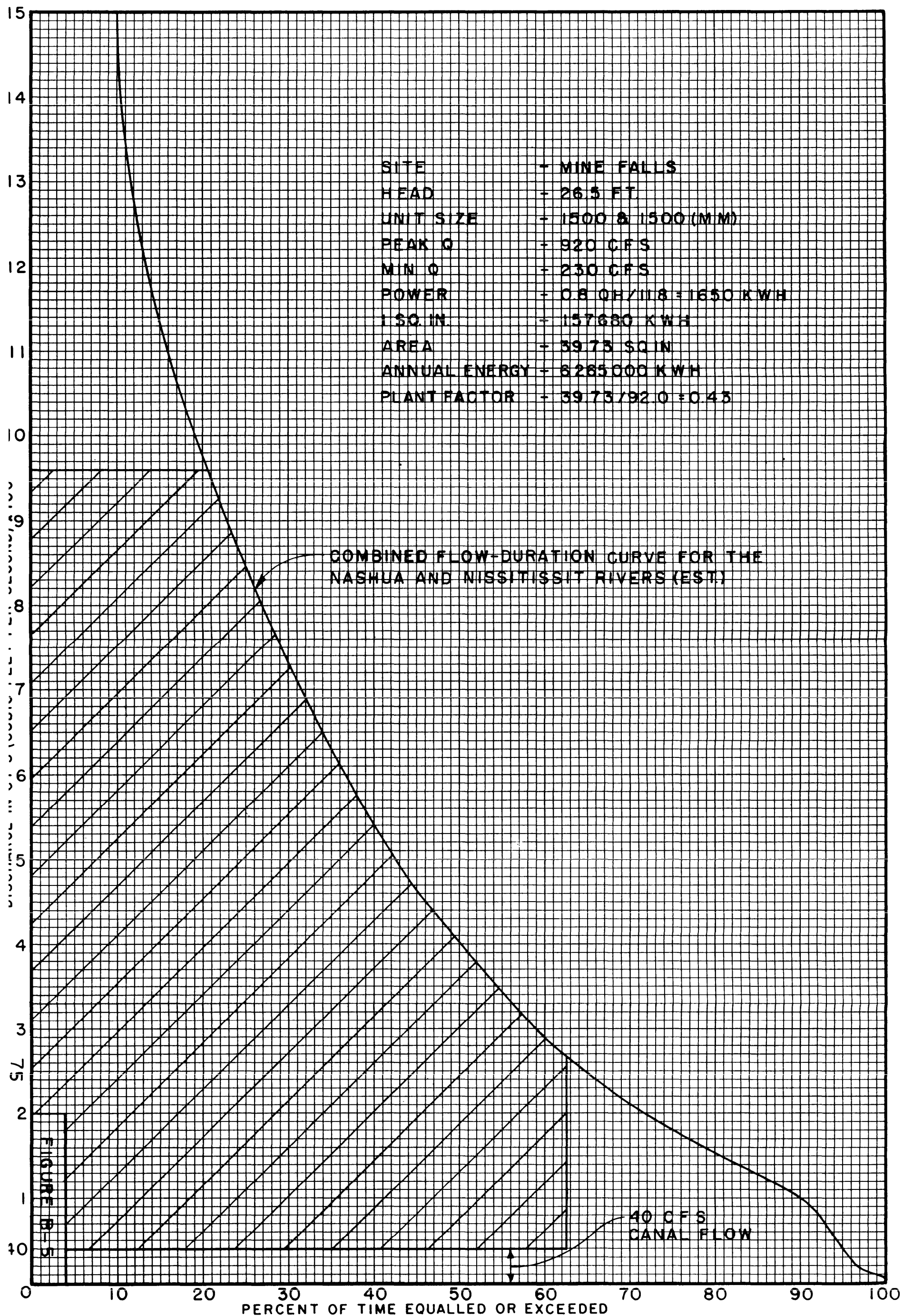
NASHUA RIVER HYDROLOGY

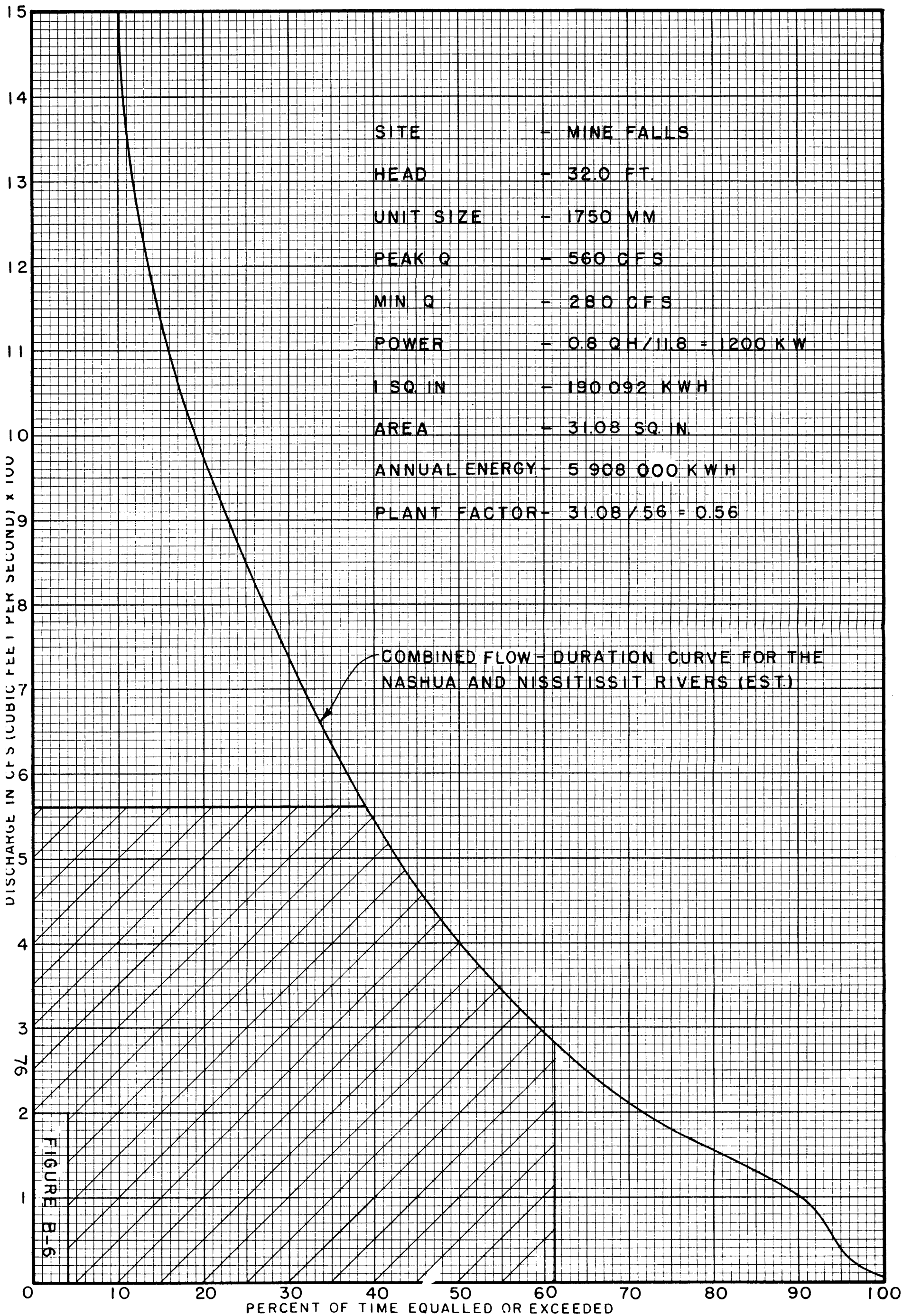


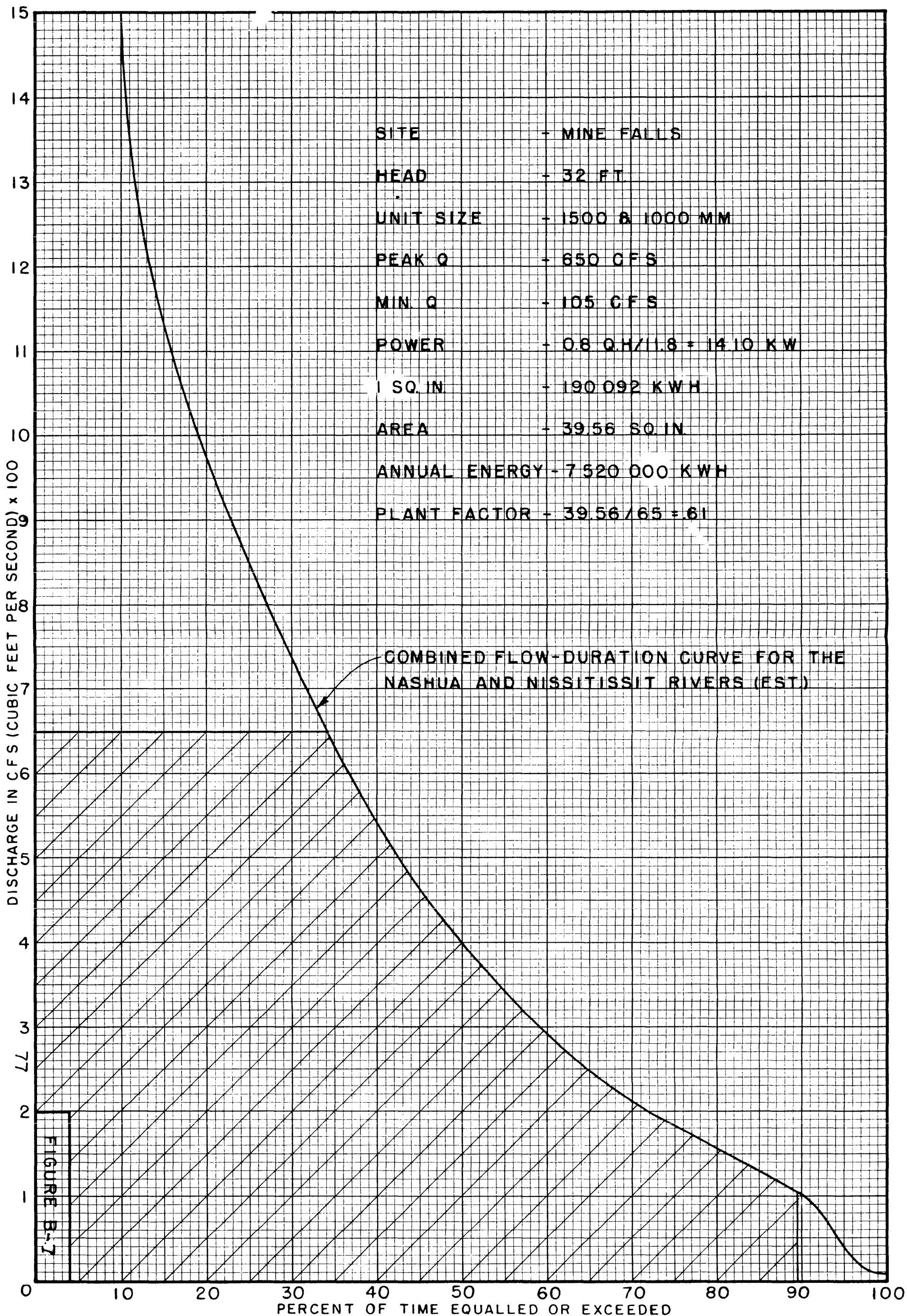




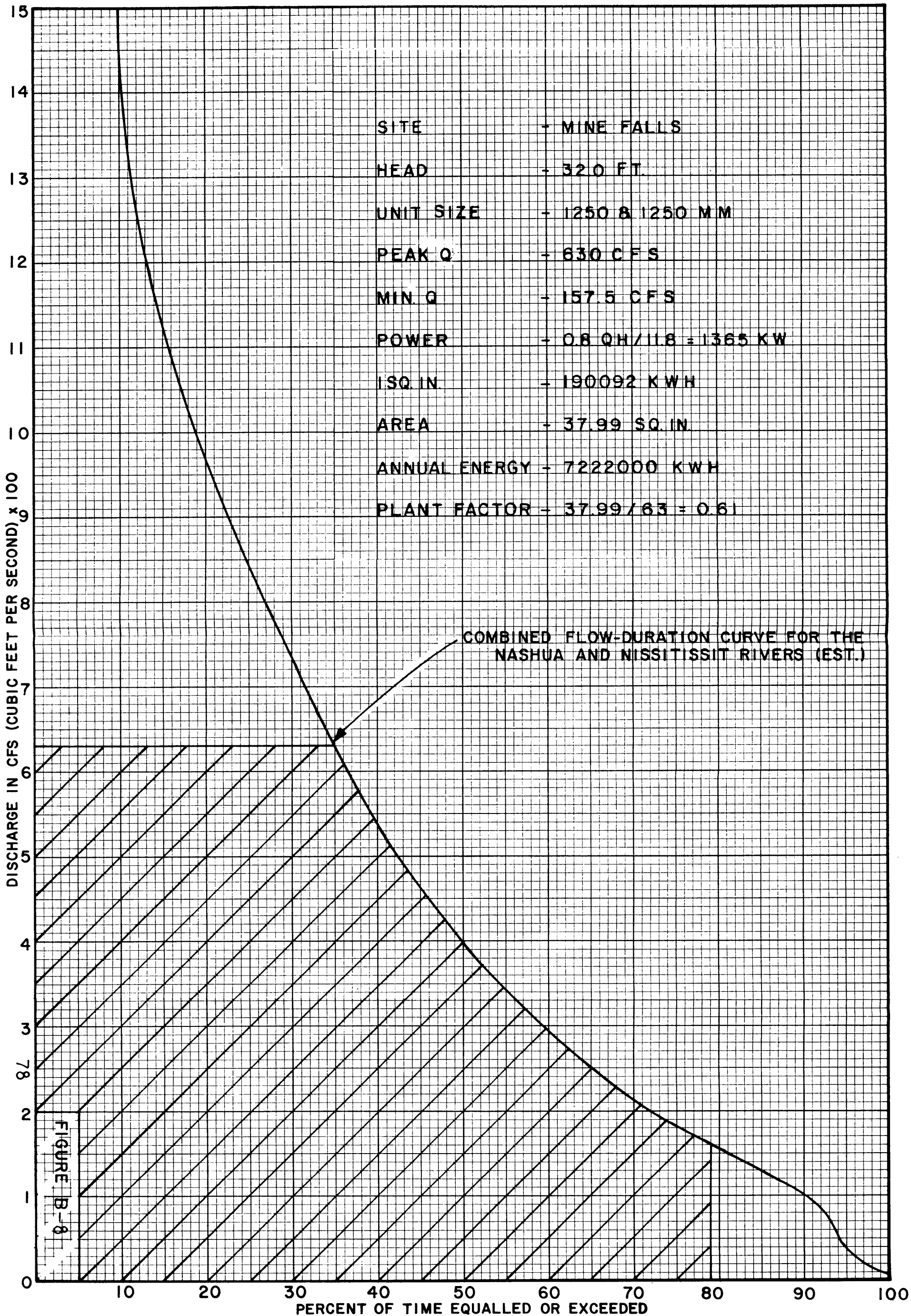
SITE = MINE FALLS
HEAD = 26.5 FT.
UNIT SIZE = 1250 S 1250 (MM)
PEAK Q = 660 CFS
MIN Q = 165 CFS
POWER = $0.8 QH/1.8 = 1185$ KW
ISO IN. = 157680 KWH
AREA = 35.13 SQ IN.
ANNUAL ENERGY = 5539000 KWH
PLANT FACTOR = $35.13/66.0 = 0.53$







SITE - MINE FALLS
HEAD - 32 FT.
UNIT SIZE - 1500 & 1000 MM
PEAK Q - 650 CFS
MIN. Q - 105 CFS
POWER - $0.8 QH/11.8 = 14.10$ KW
1 SQ. IN - 190 092 KWH
AREA - 39.56 SQ IN
ANNUAL ENERGY - 7 520 000 KWH
PLANT FACTOR - $39.56/65 = .61$



APPENDIX C - Current NH Legislation
on Small-Scale Hydro

act in improving the availability and affordability of product liability insurance; shall review other existing laws and practices which bear on the availability and affordability of such insurance; and shall recommend such changes as may be necessary to increase availability and affordability of such insurance, while at the same time allowing just compensation to those suffering injury from products.

III. An interim report shall be prepared and submitted by the commission on April 1, 1979, to the governor, the president of the senate and the speaker of the house, with a final report due on or before January 1, 1980.

31:3 Effective Date. This act shall take effect 60 days after its passage.

[Approved June 23, 1978.]

[Effective date August 22, 1978.]

CHAPTER 32. (HB 35)

AN ACT RELATIVE TO PROVIDING EXEMPTIONS FROM PUBLIC UTILITY STATUS FOR CERTAIN ELECTRICAL ENERGY PRODUCERS AND SETTING RATES FOR SALE OF POWER GENERATED BY THOSE EXEMPTED PRODUCERS.

Be it Enacted by the Senate and House of Representatives in General Court convened:

32:1 New Chapter. Amend RSA by inserting after chapter 362 the following new chapter:

CHAPTER 362-A

LIMITED ELECTRICAL ENERGY PRODUCERS ACT

362-A:1 Declaration of Purpose. It is found to be in the public interest to provide for small scale and diversified sources of supplemental electrical power to lessen the state's dependence upon other sources which may, from time to time, be uncertain.

362-A:2 Exemption of Limited Electrical Energy Producers. Producers of electrical energy, not involving the use of nuclear or fossil fuels, with a developed output capacity of not more than 5 megawatts shall not be considered public utilities and shall be exempt from all rules, regulations and statutes applying to public utilities.

362-A:3 Purchase of Output of Limited Electrical Energy Producers By Public Utilities. The entire output of electric energy of such limited electrical energy producers, if offered for sale, shall be purchased by the electric public utility which serves the franchise area in which the installations of such producers are located.

362-A:4 Payment by Public Utilities for Purchase of Output of Limited Electrical Energy Producers. Public utilities purchasing electrical energy in accordance with the provisions of this chapter shall pay a

price per kilowatt hour to be set from time to time, by the public utilities commission.

362-A: 5 Settlement of Disputes. Any dispute arising under the provisions of this chapter may be referred by any party to the public utilities commission for adjudication.

32: 2 Effective Date. This act shall take effect 60 days after its passage.

[Approved June 23, 1978.]

[Effective date August 22, 1978.]

CHAPTER 33.

AN ACT CONCERNING THE ASSIGNMENT OF TEMPORARY JUSTICES OF THE SUPREME COURT.

Be it Enacted by the Senate and House of Representatives in General Court convened:

33: 1 Justices. Amend RSA 490: 1 by striking out said section and inserting in place thereof the following:

490: 1 Justices. The supreme court shall consist of a chief justice and 4 associate justices, appointed and commissioned as prescribed by the constitution.

33: 2 Temporary Justices. Amend RSA 490: 3 by striking out said section and inserting in place thereof the following:

490: 3 —Disqualification; Temporary Justices.

I. The provisions as to the disqualification of justices of the superior court apply to justices of the supreme court. Whenever a justice of the supreme court shall be disqualified or otherwise unable to sit in any cause or matter pending before such court, the chief or senior associate justice of the supreme court may assign another justice to sit according to the provisions of paragraph II of this section.

II. Upon the retirement, disqualification, or inability to sit of any justice of the supreme court, the chief justice or senior associate justice of the supreme court may assign a justice of the supreme court who has retired from regular active service to sit during supreme court sessions while the vacancy continues, or he may notify the chief justice or senior associate justice of the superior court of such vacancy. Upon such notification, the chief justice or senior associate justice of the superior court shall provide the supreme court for each day of sitting during a session while the vacancy shall continue with the names of 2 or more superior court justices in regular active service or who are retired and are not otherwise disqualified. The chief justice or senior associate justice of the supreme court may then assign a justice to sit temporarily on the court from among those superior court justices whose names have been provided.

III. A justice assigned to sit temporarily on the supreme court pursuant to paragraph II of this section shall have all the authority of a supreme court justice to hear arguments, render decisions, and file opinions. No

10 days after the receipt of said application. The applicants for such recount shall pay to the city clerk for the use of the city a fee of \$25. At the time appointed, the city council shall meet in convention and shall recount the ballots under such rules of procedures as they shall determine.

44:18 Declaration of Result. If, in case of a recount of such votes, it shall appear that the result of the voting on said question is other than that declared upon a canvass of the votes by the city council after a municipal election, the city council shall declare the result found by it upon such recount and such declaration shall be final unless the result is changed upon appeal to the superior court.

44:19 Applicability of Election Laws. Cities holding elections on days other than those of state elections shall be governed by the provisions of RSA 658 and 659 in the choice of city and ward officers in so far as such provisions are not inconsistent with city charter provisions or other state statutes.

410:25 Further Authority. If HB 575, An Act codifying the election laws, shall not become law, the director of legislative services is hereby authorized, with the approval of the speaker of the house and the president of the senate, to make changes in the numbering of the new chapters of the RSA inserted by this act and also the numbering of any RSA section cross references both in the new chapters and elsewhere in this act, provided that no substantive changes may thereby be made. Such authority shall expire upon the printing of the 1979 session laws.

410:26 Effective Date. This act shall take effect July 1, 1979.

(Approved June 23, 1979.)

(Effective Date July 1, 1979.)

CHAPTER 411 (HB 771) (Laws of 1979)

AN ACT RELATIVE TO THE SALE OF POWER BY LIMITED
ELECTRICAL ENERGY PRODUCERS.

Be it Enacted by the Senate and House of Representatives in General Court convened:

411:1 Contracting with Private Individuals. Amend RSA 362-A by inserting after section 2 the following new section:

362-A:2-a Purchase of Output by Private Sector.

I. A limited producer of electrical energy shall have the authority to sell its produced electrical energy to not more than 3 purchasers other than the franchise electric utility. Such purchaser may be any individual, partnership, corporation or association. The public utilities commission shall review and approve all contracts concerning a retail sale of electricity pursuant to this section. The public utilities commission shall not set the terms of such contracts but may disapprove any contract which in its judgement:

(a) Fails to protect both parties against excessive liability or undue risk, or

(b) Entails substantial cost or risk to the electric utility in whose franchise area the sale takes place, or

(c) Is inconsistent with the public good.

II. Upon request of a limited producer, any franchised electrical public utility in the transmission area shall transmit electrical energy from the producer's facility to the purchaser's facility in accordance with the provisions of this section. The producer shall compensate the transmitter for all costs incurred in wheeling and delivering the current to the purchaser. The public utilities commission must approve all such agreements for the wheeling of power and retains the right to order such wheeling and to set such terms for a wheeling agreement including price that it deems necessary. The public utilities commission or any party involved in a wheeling transaction may demand a full hearing before the commission for the review of any and all of the terms of a wheeling agreement.

III. Before ordering an electric utility to wheel power from a limited electric producer or before approving any agreement for the wheeling of power, the public utilities commission must find that such an order or agreement:

(a) is not likely to result in a reasonably ascertainable uncompensated loss for any party affected by the wheeling transaction.

(b) will not place an undue burden on any party affected by the wheeling transaction.

(c) will not unreasonably impair the reliability of the electric utility wheeling the power.

(d) will not impair the ability of the franchised electric utility wheeling the power to render adequate service to its customers.

411:2 Gross Sales. Amend RSA 362-A:3 (supp) as inserted by 1978, 32:1 by striking out said section and inserting in place thereof the following:

362-A:3 Purchase of Output of Limited Electrical Energy Producers by Public Utilities. The entire output of electric energy of such limited electrical energy producers, if offered for sale to the electric utility, shall be purchased by the electric public utility which serves the franchise area in which the installations of such producers are located. No electric public utility shall be required to purchase the entire output of electric energy if the amount of the purchase exceeds 10 percent of the utility's gross sales of electricity.

411:3 Effective Date. This act shall take effect 60 days after its passage.

(Approved June 23, 1979.)

(Effective Date August 22, 1979.)

NEW HAMPSHIRE

1978 SPECIAL SESSION

House Bill No. 35 was passed by the Legislature and became Chapter 32 of the Laws of 1978, Special Session. Chapter 32 inserted CHAPTER 362-A in the New Hampshire Revised Statutes Annotated.

1979 REGULAR SESSION

House Bill No. 771 was passed by the Legislature and became Chapter 411 of the Laws of 1979. This inserted a new section in RSA 362-A: 362-A:2-a; and amended 362-A:3; so that section 362-A:3 should now read as amended by Chapter 411 of the Laws of 1979.

(When the 1979 SUPPLEMENTS to the Revised Statutes Annotated are printed, Chapter 362-A will be as amended by the 1979 Legislature.)

APPENDIX D - NH Public Utilities Commission
Report on Rates

CHAIRMAN
MICHAEL LOVE
COMMISSIONERS
FRANCIS J. RIORDAN
MALCOLM J. STEVENSON



VINCENT J. IACOPINO
SECRETARY

DE 78-232

DE 78-233

State of New Hampshire

PUBLIC UTILITIES COMMISSION

Concord 03301

Telephone Area Code 603

271-2452

PRESS RELEASE
April 19, 1979

The New Hampshire Public Utilities Commission issued its report today establishing a price to be paid by electric utilities for purchase of energy from limited electrical energy producers, such as operators of small hydro-electric plants. A price of 4.5¢ per kilowatt-hour is established for energy from plants which produce such energy on a dependable capacity basis, while 4.0¢ per kilowatt-hour is set for energy from those plants which produce such energy on a non-dependable capacity basis (such as run-of-the-river hydro plants).

In its decision, the Commission stated that it was guided by the intent of legislation recently passed by the New Hampshire Legislature and the United States Congress, both of which call for the development of small-scale and diversified sources of supplemental electric power, and the conservation of fossil fuels.

The Commission pointed out that Federal rules have not as yet been promulgated to fully implement the Federal legislation, but at the time such rules become available the Commission will re-evaluate its present decision.

The Commission also indicated that annual adjustments of the prices set will be in order.

NEW HAMPSHIRE ELECTRIC COOPERATIVE, INC.

DE 78-233

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

Rate for Sale of Energy by Limited Electrical Energy Producers

..00..

ORDER NO. 13,589

Upon consideration of the foregoing Report, which is made a part hereof; it is

ORDERED, that pursuant to the provisions of PURPA and RSA 362-A:4, public electric utilities purchasing electrical energy from Limited Electric Energy Producers operating plants in the utility's franchise area, not involving the use of nuclear or fossil fuels, with a developed output capacity of not more than five (5) Megawatts, shall pay for the entire output of electric energy, if offered for sale, a price for the next twelve (12) months for all energy purchased on and after May 1, 1979, as follows:

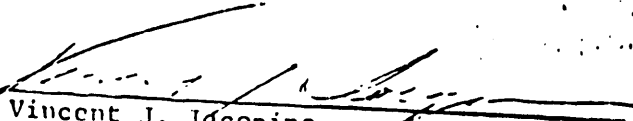
- A. From plants which produce energy on a non-dependable capacity basis (such as run-of-the-river hydro plants) - Four (4) cents per kilowatt-hour (KWH);
- B. From plants which produce energy on a dependable capacity - Four and one-half (4.5) cents per kilowatt-hour (KWH);

and it is

FURTHER ORDERED, that the Commission will re-examine the PURPA issues in this proceeding upon the issuance of rules by the FERC; and it is

FURTHER ORDERED, that it is the intent of this Commission that subsequent annual adjustments will be made.

By order of the Public Utilities Commission of New Hampshire this eighteenth day of April 1979.


Vincent J. Iacopino
Executive Director and Secretary

APPENDIX E - Regulatory and Licensing

Docket No. RM78-9

APPLICATION FOR SHORT-FORM LICENSE (MINOR)

1. Applicant's full name and address: _____

(Zip Code)

2. Location of Project:
State: _____ County: _____
Nearest town: _____ Water body: _____

3. Project description and proposed mode of operation
(reference to Exhibits K and L, as appropriate):

(continue on separate sheet, if necessary)

4. Lands of the United States affected (shown on Exhibit K)
(Name) (Acres)

- a. National Forest _____
b. Indian Reservation _____
c. Public Lands Under
Jurisdiction of _____
d. Other _____
e. Total U.S. Lands _____
f. Check appropriate box:

☒ Surveyed ☐ Unsurveyed land in public-land
state:

(1) If surveyed land in public-land state provide the
following:

Sections and subdivisions: _____

Range _____ Township: _____

Principal base and meridian: _____

(2) If unsurveyed or not in public-land state, see
Item 8 of instructions: _____

5. Purposes of project (use of power output, etc.)

Docket No. RM78-9

6. Construction of the project is planned to start _____
it will be completed within _____ months from the date of
issuance of license.
7. List here and attach copies of State water permits or other
permits obtained authorizing the use or diversion of water,
or authorizing (check appropriate box):
☐ the construction, operation, and maintenance
☐ the operation and maintenance
of the proposed project.
8. Attach an environmental report prepared in accordance
with the requirements set forth in the Instructions for
Completing Application for Short-Form License (Minor),
below.
9. Attach Exhibits K and L drawings.
10. State of _____ ss:
County of _____

being duly sworn, depose(s) and say(s) that the contents of
this application are true to the best of _____ knowledge or
belief and that (check appropriate box)

☐ _____ is (are) a citizen(s) of the United States
☐ all members of the association are citizens of the
United States

☐ _____ is (are) the duly appointed agent(s) of the
state (municipality) (corporation) (~~association~~)
and has (have) signed this application this _____ day of _____,
19____.

(Applicant(s))

Docket No. RM78-9

By _____
Subscribed and sworn to before me, a Notary Public of the
State of _____, this ____ day of _____,

/SEAL/

(Notary Public)

Docket No. RM78-9

INSTRUCTIONS FOR COMPLETING APPLICATION
FOR SHORT-FORM LICENSE (MINOR)

GENERAL

1. This application may be used if the proposed or existing project will have or has a total generating capacity of not more than 1,500 kW (2,000 horsepower). Advice regarding the proper procedure for filing should be requested from the Federal Energy Regulatory Commission in Washington, D. C.; or from one of the Commission's Regional Offices in Atlanta, Chicago, Fort Worth, New York, or San Francisco.

2. This application is to be completed and filed in an original and nine copies with the Federal Energy Regulatory Commission, 825 N. Capitol Street, N.E., Washington, D. C.

20426. Each of the original and the nine copies of the application is to be accompanied by:

- a. One copy each of Exhibits K and L described below.
- b. One copy each of a state water quality certificate pursuant to Section 401 of the Federal Water Pollution Control Act (or evidence that this certificate is not needed), and any water rights certificate or similar evidence required by state law relating to use or diversion of water. In lieu of submitting a copy of a Section 401 certificate (or other certificate), evidence that applications for these certificates have been filed with appropriate agencies, or that such certificates are not necessary, will be adequate to begin FERC processing of the application.
- c. One copy each of any other state approvals necessary. (Applicant should contact the state natural resources department or equivalent to ascertain whether any such approvals are necessary.)

Docket No. RM78-9

- d. One copy of Applicant's environmental report, described below.

3. Applicant is required to consult with appropriate Federal, State, and local resources agencies during the preparation of the application and provide interested agencies with the opportunity to comment on the proposal prior to its filing with the Commission. The comments of such agencies must be attached to the application when filed. A list of agencies to be consulted can be obtained from the Commission's main office or the appropriate regional office.

4. No work may be started on the project until receipt of a signed license from the Commission. The application itself does not authorize entry upon Federal land for any purpose. If the project is located in part or in whole upon Federal land, the Applicant should contact the appropriate land management agency regarding the need to obtain a right-of-way permit. As noted above, other state or Federal permits may be required.

5. An applicant must be: a citizen or association of citizens of the United States; a corporation organized under the laws of the United States or a State; a State; or a municipality.

- (a) If the applicant is a natural person, include an affidavit of United States citizenship.
- (b) If the applicant is an association, include one verified copy of its articles of association. If there are no articles of association, that fact shall be stated over the signature of each member of the association. Also include a complete list of members and a statement of the citizenship of each in an affidavit by one of them.

Docket No. RM78-9

- (c) If the applicant is a corporation, include one copy of the charter or certificate and articles of incorporation, with all the amendments, duly certified by the secretary of state of the State where organized, and one copy of the by-laws. If the project is located in a state other than that in which the corporation is organized, include a certificate from the secretary of state of the State in which the project is located showing compliance with the laws relating to foreign corporations.
- (d) If the applicant is a state, include a copy of the laws under the authority of which the application is made.
- (e) If the applicant is a municipality as defined in the Federal Power Act, include one copy of its charter or other organization papers, duly certified by the secretary of state of the State in which it is located, or other proper authority. Also include a copy of the State laws authorizing the operations contemplated by the application.

Include a copy of all minutes, resolutions of stockholders or directors, or other representatives of the applicant, properly attested, authorizing the filing of the application. This information can be provided by a letter attached to the application.

6. If the stream or water body is unnamed, give the name of the nearest named stream or water body to which it is tributary.

Docket No. RM78-9

7. The project description (application item 3) shall include, as appropriate: the number of generating units, including auxiliary units, the capacity of each unit, and provisions, if any, for future units; type of hydraulic turbine(s); a description of how the plant is to be operated, manual or automatic, and whether the plant is to be used for peaking; estimated average annual generation in kilowatt-hours or mechanical energy equivalent; estimated average head on the plant; reservoir surface area in acres and, if known, the net and gross storage capacity; estimated hydraulic capacity of the plant (flow through the plant) in cubic feet per second; estimated average flow of the stream or water body at the plant or point of diversion; sizes, capacities, and construction materials, as appropriate, of pipelines, ditches, flumes, canals, intake facilities, powerhouses, dams, transmission lines, etc.; and estimated cost of the project.

8. In the case of unsurveyed public land, or land not in a public-lands state, give the best legal description available. Include the distance and general direction from the nearest city or town, fixed monument, physical features, etc.

9. Exhibits K and L shall be submitted on separate drawings. Drawings for Exhibits K and L shall have identifying title blocks and bear the following certification: "This drawing is a part of the application for license made by the undersigned this ____ day of _____, 19____.

(Name of Applicant)

Docket No. RM78-9

10. The Commission reserves the right to require additional information, or another filing procedure, if data provided indicate such action to be appropriate.

EXHIBIT K-PROJECT LANDS AND BOUNDARIES

1. The Exhibit K is a planimetric map showing the portion of the stream developed, the location of all project works, and other important features, such as: the dam or diversion structure, reservoir pipeline, powerplant, access roads, transmission lines, project boundary, private land ownerships (clearly differentiate between fee ownership and land over which applicant only owns an easement), and Federal land boundaries and identifications.

2. The map shall be an ink drawing or drawing of similar quality on a sheet not smaller than 8 inches by 10-1/2 inches, drawn to a scale no smaller than one inch equals 1,000 feet. Ten legible prints shall be submitted with the application. Upon request after review of the application, the tracing must be submitted.

3. The project boundary shall be drawn on the map so that the relationship of each project facility and reservoir to other property lines can be determined. The boundary shall enclose all project works, such as the dam, reservoir, pipelines, roads, powerhouse, and transmission lines. The boundary shall be set at the minimum feasible distance from project works necessary to allow operation and maintenance of the project and control of the shoreline and reservoir. The distance in feet from each principle facility to the boundary shall be shown. The project boundary should be a surveyed line with stated courses and distances. A tape-compass survey is acceptable. True north shall be indicated on the map.

Docket No. RM78-9

The area of Federal land in acres within the project boundary shall be shown. The appropriate Federal agency should be contacted for assistance in determining the Federal land acreage. For clarity, use inset sketches to a larger scale than that used for the overall map to show relationships of project works, natural features, and property lines.

4. Show one or more ties by distance and bearing from a definite, identifiable point or points on project works or the project boundary to established corners of the public land survey or other survey monuments, if available.

5. If the project affects unsurveyed Federal lands, the protraction of township and section lines shall be shown. Such protractions, whenever available, shall be those recognized by the agency of the United States having jurisdiction over the lands. On unsurveyed lands, show ties by distance and bearing to fixed recognizable objects.

6. If the project uses both Federal and private lands, the detailed survey descriptions discussed above for the project boundary apply only to Federal lands. General location data and an approximate project boundary will normally suffice for project works on private lands.

EXHIBIT L-PROJECT STRUCTURES AND EQUIPMENT

1. The exhibit shall be a simple ink drawing or drawing of similar quality on a sheet no smaller than 8 inches by 10-1/2 inches, drawn to a scale no smaller than one inch equals 50 feet for plans and profiles, and one inch equals 10 feet for sections. Ten legible prints shall be submitted with the application. Upon request after initial review of the application, tracings must be submitted.

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2. The drawing shall show a plan, elevation, and section of the diversion structure and powerplant. Generating and auxiliary equipment proposed should be clearly and simply depicted and described. Include a north arrow on the plan view.

ENVIRONMENTAL REPORT

The environmental report should be consistent with the scope of the project and the environmental impacts of the proposed action; e.g., authorization to operate and maintain an existing project, or a project using an existing dam or other facility, would require less detailed information than authorization to construct a new project. The environmental report shall set forth in a clear and concise manner:

- (1) A brief description of the project and the mode of operation, i.e., run-of-river, peaking or other specific mode.
- (2) A description of the environmental setting in and near the project area, to include vegetative cover, fish and wildlife resources, water quality and quantity, land and water uses, recreational use, socio-economic aspects, historical and archeological resources, and visual resources. Special attention shall be provided endangered and threatened plant and animal species, critical habitats, and sites eligible for or included on the National Register of Historic Places. Assistance in the preparation of this information may be obtained from state natural resources departments and from local offices of Federal natural resources agencies.

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- (3) A description of the expected environmental impacts resulting from the continued operation of an existing project, or from the construction and operation of a new project or a project using an existing dam or other existing facility. Include a discussion of specific measures proposed by the Applicant and others to protect and enhance environmental resources and to mitigate adverse impacts of the project on the environmental resources and values, the cost of those measures, and the party undertaking to implement those measures if other than the Applicant.
- (4) A description of alternative means of obtaining an amount of power equivalent to that provided by the project in the event that construction or continued operation of the project is not authorized.
- (5) A description of the steps taken by the Applicant in consulting with Federal, state, and local agencies during the preparation of the environmental report. Indicate which agencies have received the final report and provide copies of letters containing the comments of those agencies.

REGULATION OF SMALL DAMS IN NEW HAMPSHIRE (I)
as applies to
FEASIBILITY OF MINE FALLS DAM AND JACKSON MILLS DAM

(I.) Excerpted from "Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire", by the Energy Law Institute, Franklin Pierce Law Center, Concord, New Hampshire.

Anderson-Nichols & Company, Inc. is solely responsible for its interpretation as presented herein.

HYDROELECTRIC PROJECT

OWNERSHIP

- does the developer have the legal right to use of the flowing water?
- does the developer own both banks?
- is the water navigable, public or non-navigable?

See Flow Diagram for Federal Regulations

Apply to state legislature for legislative charter conferring the use and enjoyment of the water course to the developer.
-Public Trust Doctrine.

Denied

Approved

Apply: for major dam construction permit with Water Resources Board

If developer is private entity or municipality

File statement with Water Resources Board

Water Resources Board determines if dam will be a menace to public safety if improperly constructed

NO

YES

File plans and specifications with Water Resources Board

Determine: effect on other interests and apply for necessary permits with appropriate agencies
- dredge and fill and state water quality certificate from Water Supply and Pollution Control Commission
- dredge and fill in wetlands from Water Resources Board (Special Board)
- Department of Fish & Game determination of need for fishladder(s)

Approved

Denied

Successful

Appeal to State Court

Will the dam generate in excess of 5 megawatts or be a municipal corporation operating outside the corporate limits?

NO

Dam is not a public utility

Construction, operation and maintenance of dam.
-comply with conditions of all permits
-utilize Mill Act

File Petition with Water Resources Board. Water Resources Board holds hearing

Denied

Approved

See Flow Diagram for Federal Regulations

FLOW DIAGRAM
FOR THE
STATE REGULATIONS

Anderson-Nichols & Co., Inc.
Concord New Hampshire

U.S. Army Engineer Div. New England
Corps of Engineers
Waltham, MA

FEDERAL REGULATION OF SMALL DAMS
by the
FEDERAL ENERGY REGULATORY COMMISSION REGULATION⁽¹⁾

(1) Excerpted from (Draft) Federal Legal Obstacles and Incentives to the Development of the Small Scale Hydroelectric Potential of the Nineteen Northeastern United States by the Energy Law Institute, Franklin Pierce Law Center, Concord, New Hampshire. Anderson-Nichols & Company, Inc. is solely responsible for its interpretation as presented herein.

HYDROELECTRIC PROJECT

File: Declaration of Intent to allow F.E.R.C. to determine jurisdiction
- mandatory for all new projects

Is project under F.E.R.C. jurisdiction?
- Is project located on or does it affect navigable waterway?
- Is project connected to interstate grid?

YES

Comply with state and local requirements
See flow diagram for State Regulations

File: Preliminary Permit Application
- preference to public entities

permit granted (or permit process bypassed)

Prepare F.E.R.C. license application if project will generate less than 1.5 mw.

Prepare Short Form (minor) License
- secure data
- briefly describe environmental impact, and

- acquire land water rights
- sign contract for sale of power
- consult with Fish & Wildlife agencies
- consult with Historical & Archeological Preservation agencies
- consult list of Endangered Species
- consult Wild & Scenic Rivers designations
- consult National Trails System
- obtain S 404 dredge and fill permit
- obtain S 401 state water quality certification and other state permits

See flow diagram for State Regulations

File: License application with F.E.R.C. which review for deficiencies

Accepted and Docketed

F.E.R.C. begins processing license application

Application section appoints project manager, reviews for general adequacy

Environmental analysis section reviews impact, decides if EIS required

No EIS required for minor (< 1.5 mw) projects
(negative determination prepared)

Project Manager receives comments by F.E.R.C. office on application

Project Manager prepares Power Memorandum
- Office of General Council prepares Commission Order

Commissioners receive Power Memorandum, final EIS, Commission Order

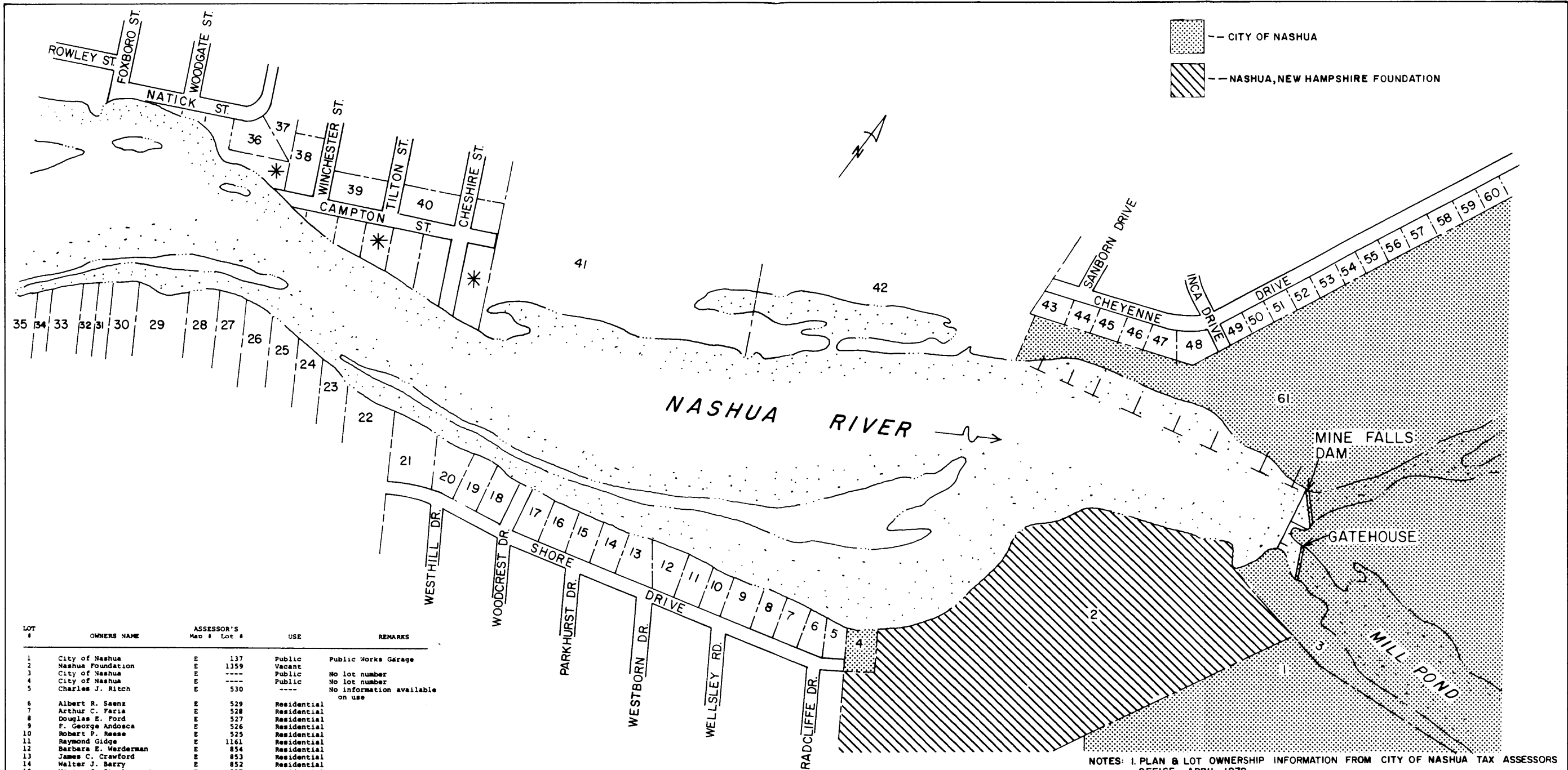
Commission Acts on License application
- is the project that best adapted to the comprehensive development of the waterway
- is the project best developed by the Federal government?
- is the project in the public interest?

APPROVED

FLOW DIAGRAM
FOR THE
FEDERAL REGULATIONS

Anderson-Nichols & Co., Inc. U.S. Army Engineer Div. New England
Concord New Hampshire Corps of Engineers
Waltham, MA

APPENDIX F - Plates



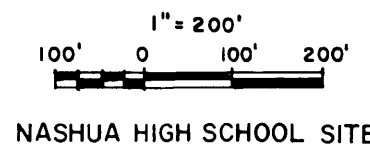
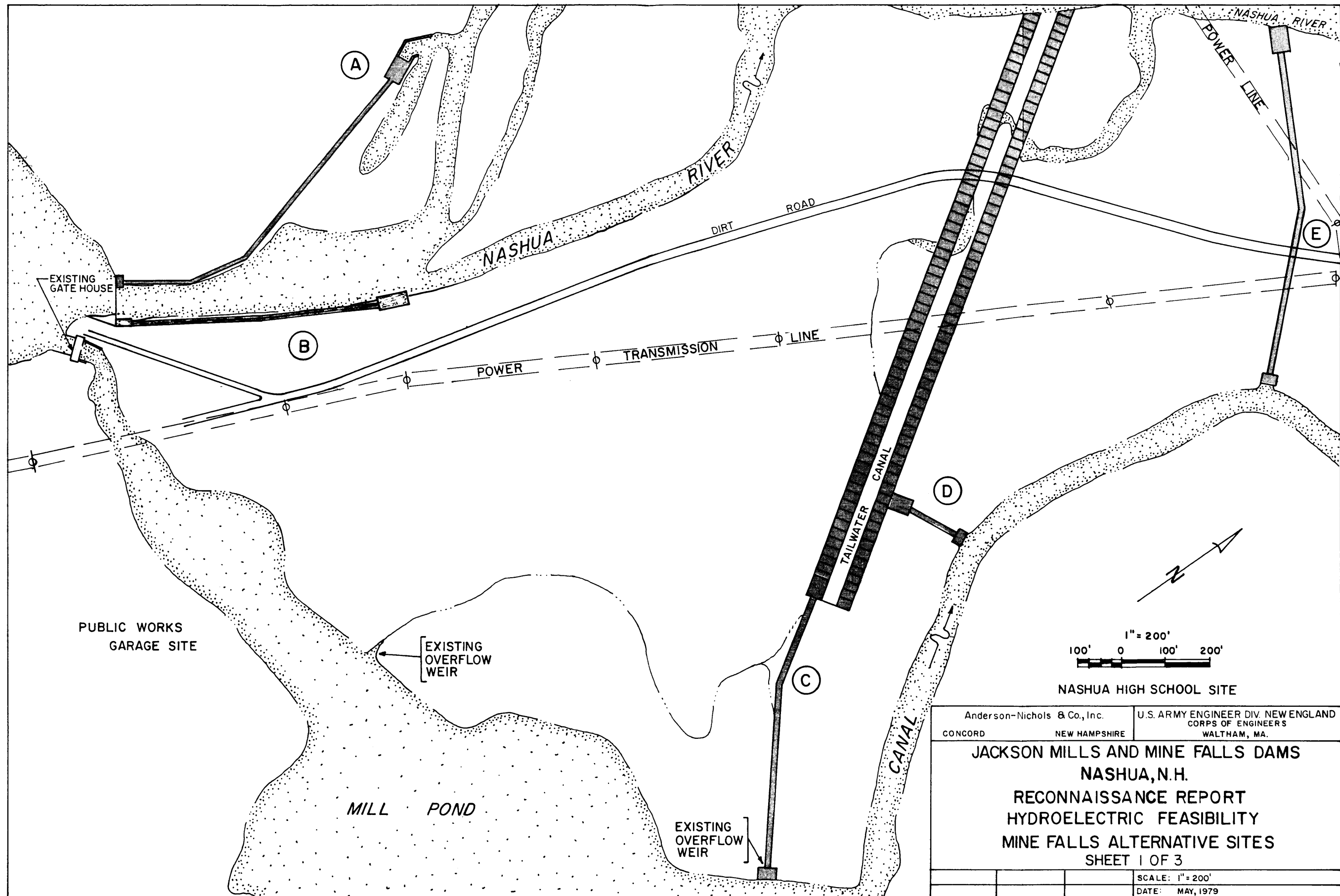
| LOT # | OWNERS NAME | ASSESSOR'S Map # Lot # | USE | REMARKS |
|-------|---|------------------------|-------------|-----------------------------------|
| 1 | City of Nashua | E 137 | Public | Public Works Garage |
| 2 | Nashua Foundation | E 1359 | Vacant | |
| 3 | City of Nashua | E ---- | Public | No lot number |
| 4 | City of Nashua | E ---- | Public | No lot number |
| 5 | Charles J. Ritch | E 530 | ---- | No information available on use |
| 6 | Albert R. Saenz | E 529 | Residential | |
| 7 | Arthur C. Faria | E 528 | Residential | |
| 8 | Douglas E. Ford | E 527 | Residential | |
| 9 | F. George Andosca | E 526 | Residential | |
| 10 | Robert P. Reese | E 525 | Residential | |
| 11 | Raymond Gidge | E 1161 | Residential | |
| 12 | Barbara E. Werderman | E 854 | Residential | |
| 13 | James C. Crawford | E 853 | Residential | |
| 14 | Walter J. Barry | E 852 | Residential | |
| 15 | Vivian J. St. Laurent | E 887 | Residential | |
| 16 | Barry J. Palmer | E 969 | Residential | |
| 17 | David D. Loseau | E 998 | Residential | |
| 18 | James M. Addonizio | E 1156 | Residential | |
| 19 | Paul C. Coppens | E 1155 | Residential | |
| 20 | James T. Garasky | E 1154 | Residential | |
| 21 | Edward P. Kelly | E 1153 | Residential | |
| 22 | Sterling-Warner Industrial Investment Corporation | F 67 | Residential | |
| 23 | Sterling-Warner Industrial Investment Corporation | F 68 | Residential | |
| 24 | William G. Robbins | F 66 | Commercial | Camp |
| 25 | William G. Robbins | F 65 | Commercial | Camp |
| 26 | Wina K. Pitarsky | F 64 | Residential | |
| 27 | Eunice E. Hoy | F 63 | Residential | |
| 28 | Eunice E. Hoy | F 62 | Residential | |
| 29 | Pitarsky Homes Inc. | F 61 | Vacant | |
| 30 | Reginald G. Walker | F 60 | Residential | |
| 31 | Reginald G. Walker | F 59 | Residential | |
| 32 | Albert J. Levesque | F 70 | Residential | No info available on use |
| 33 | Albert J. Levesque | F 70 | Residential | |
| 34 | Albert J. Levesque | F 57 | Vacant | |
| 35 | Wilfred O. Dupont | F 56 | Residential | |
| 36 | Howard Rainey | F 255 | Residential | |
| 37 | ----- | F 258 | ---- | No info available on owner or use |
| 38 | Fred D. Tirrel & Nicholas E. Zamposi | F 786 | Residential | |
| 39 | Fred D. Tirrel & Nicholas E. Zamposi | F 788 | Residential | |
| 40 | Fred D. Tirrel & Nicholas E. Zamposi | F 787 | Residential | |

| LOT # | OWNERS NAME | ASSESSOR'S Map # Lot # | USE | REMARKS |
|-------|----------------------|------------------------|-------------|--------------------------|
| 41 | A. Jasalavich | F 6 | Residential | |
| 42 | Nashua Sand & Gravel | F 7 | Commercial | |
| 43 | Marcel Trepanier | E 1176 | Residential | |
| 44 | Fredrick Lozier | E 1175 | Residential | |
| 45 | William R. Neville | E 1174 | Residential | |
| 46 | Robert Robinson | E 1173 | Residential | |
| 47 | John H. Hoffman | E 1172 | Residential | |
| 48 | Edward C. Gassman | E 1171 | Residential | |
| 49 | Thomas E. Williams | E 1170 | Residential | |
| 50 | Steven J. Salvi | E 1169 | Residential | |
| 51 | Loring E. Clark | E 1168 | Residential | |
| 52 | Gunnar I. Kahlike | E 1167 | ---- | No info available on use |
| 53 | Ricard I. Grohosky | E 1166 | Residential | |
| 54 | Anthony Storace | E 1165 | Residential | |
| 55 | Andre J. Duquette | E 1164 | Residential | |
| 56 | Michael C. Towle | E 1163 | Residential | |
| 57 | George W. Preston | E 1162 | Residential | |
| 58 | Guy P. Riendeau | E 1214 | Residential | |
| 59 | Robert B. Masek | E 1213 | Residential | |
| 60 | Richard A. Newell | E 878 | Residential | |
| 61 | City of Nashua | F ---- | Public | No lot number |

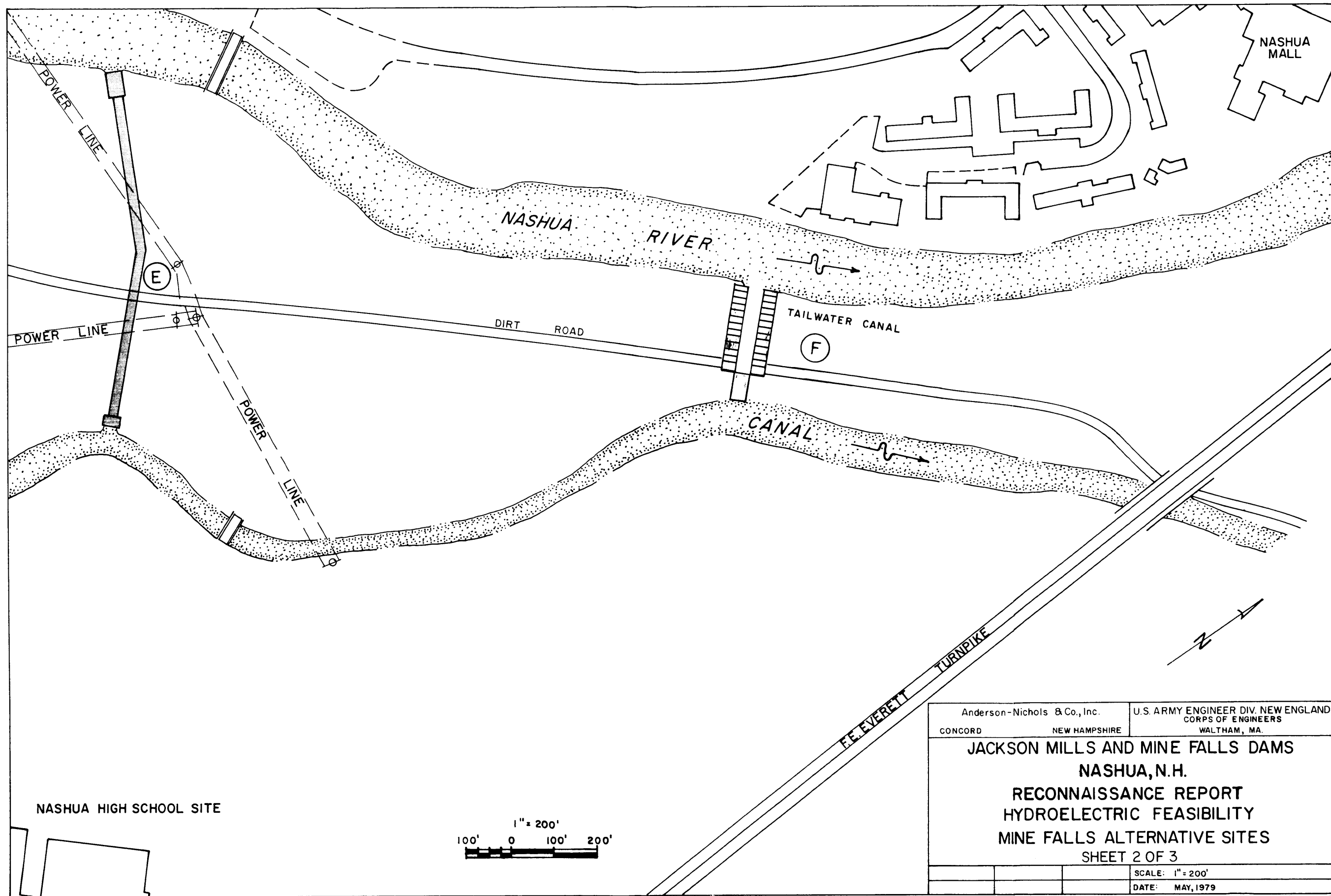
NOTES: 1. PLAN & LOT OWNERSHIP INFORMATION FROM CITY OF NASHUA TAX ASSESSORS OFFICE, APRIL 1979

2. * INDICATES NO INFORMATION AVAILABLE

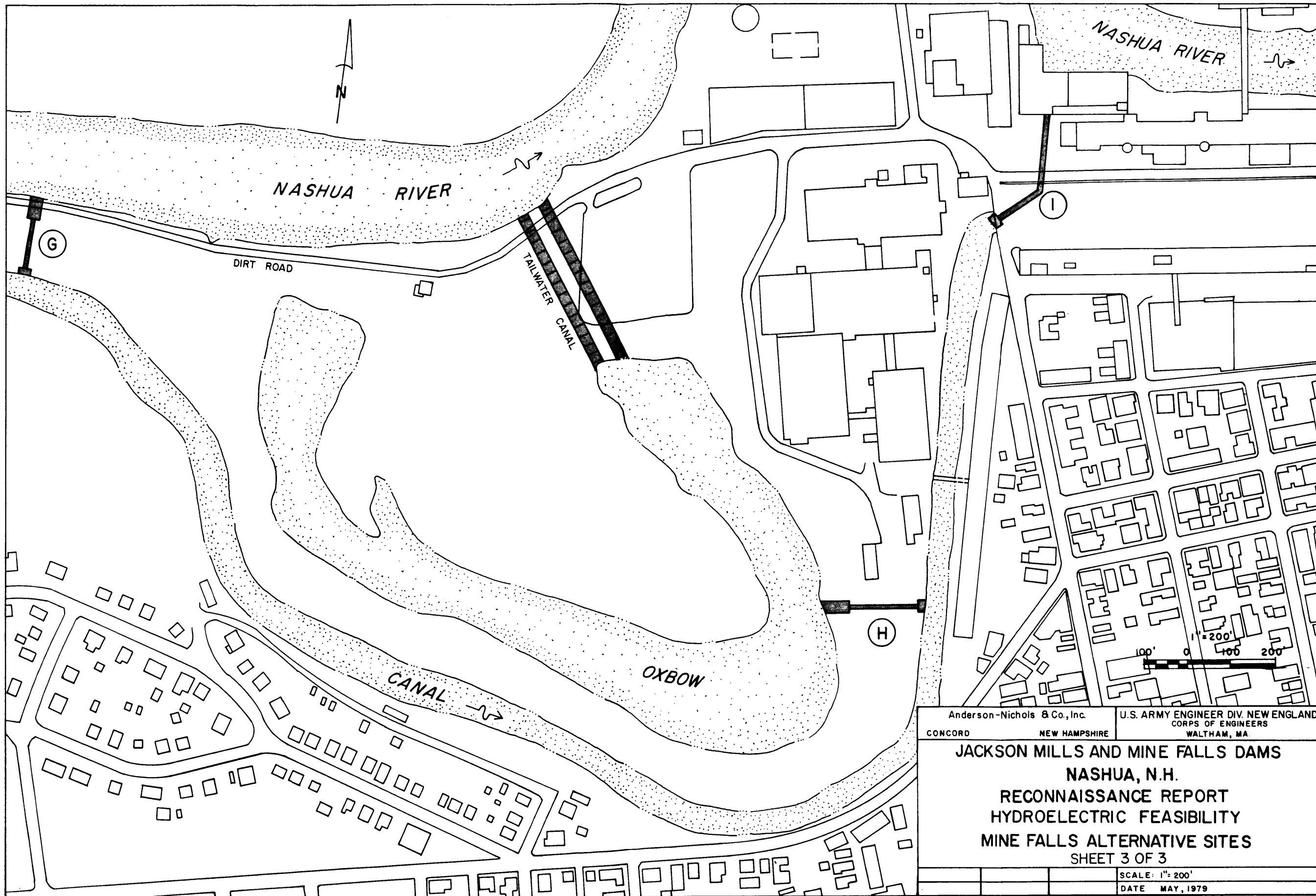
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| Anderson - Nichols & Co., Inc. | U.S. ARMY ENGINEER DIV. NEW ENGLAND |
| CONCORD | CORPS OF ENGINEERS |
| NEW HAMPSHIRE | WALTHAM, MA. |
| JACKSON MILLS AND MINE FALLS DAMS | |
| NASHUA, N.H. | |
| RECONNAISSANCE REPORT | |
| HYDROELECTRIC FEASIBILITY | |
| MINE FALLS DAM | |
| PLAN OF ABUTTING LAND | |
| SCALE: NOT TO SCALE | |
| DATE: MAY, 1979 | |



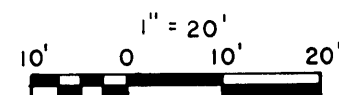
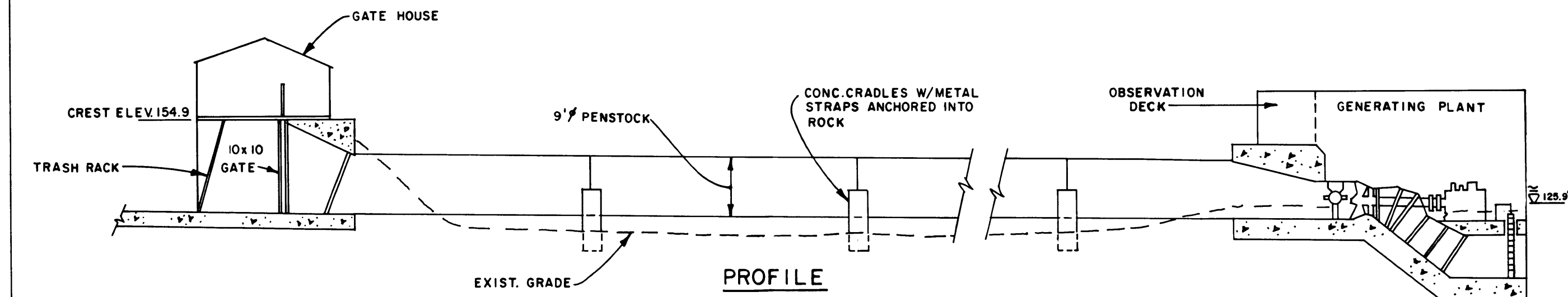
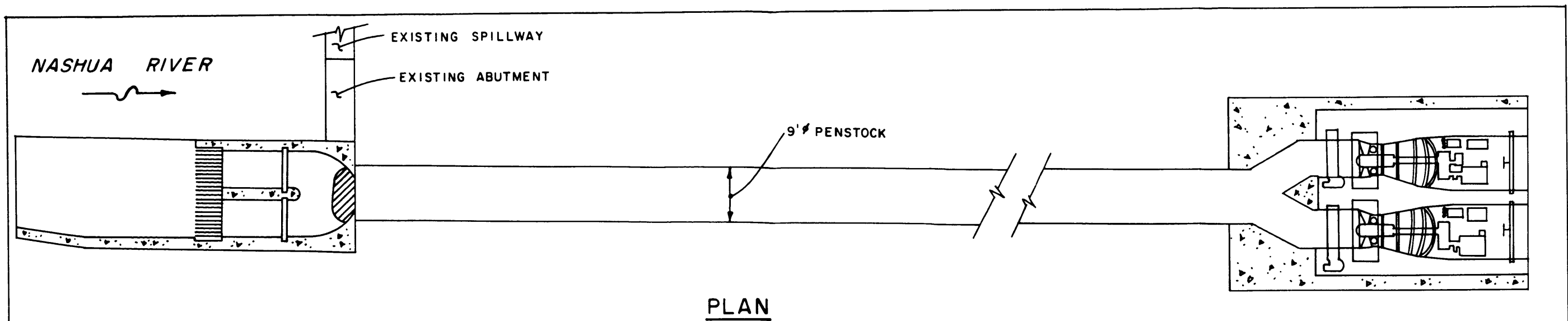
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| Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE | | U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA. |
| JACKSON MILLS AND MINE FALLS DAMS NASHUA, N.H. | | |
| RECONNAISSANCE REPORT HYDROELECTRIC FEASIBILITY MINE FALLS ALTERNATIVE SITES | | |
| SHEET 1 OF 3 | | |
| | | SCALE: 1" = 200' |
| | | DATE: MAY, 1979 |



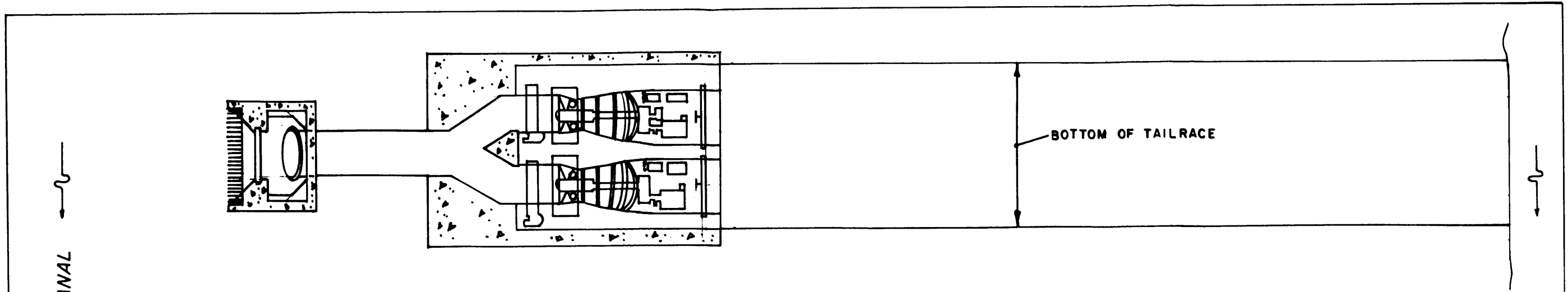
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| Anderson-Nichols & Co., Inc. | | U.S. ARMY ENGINEER DIV. NEW ENGLAND | |
| CONCORD | | CORPS OF ENGINEERS | |
| NEW HAMPSHIRE | | WALTHAM, MA. | |
| JACKSON MILLS AND MINE FALLS DAMS | | | |
| NASHUA, N.H. | | | |
| RECONNAISSANCE REPORT | | | |
| HYDROELECTRIC FEASIBILITY | | | |
| MINE FALLS ALTERNATIVE SITES | | | |
| SHEET 2 OF 3 | | | |
| | | | SCALE: 1" = 200' |
| | | | DATE: MAY, 1979 |



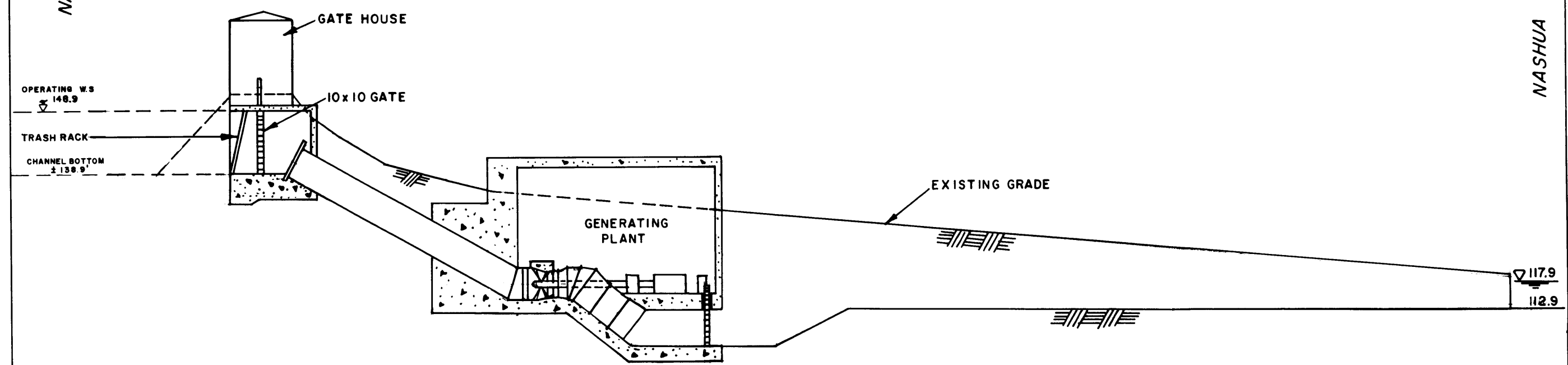
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| Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE | U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA |
| JACKSON MILLS AND MINE FALLS DAMS NASHUA, N.H. RECONNAISSANCE REPORT HYDROELECTRIC FEASIBILITY MINE FALLS ALTERNATIVE SITES SHEET 3 OF 3 | |
| SCALE: 1" = 200' | |
| DATE MAY, 1979 | |



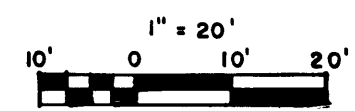
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| | | | U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA. |
| JACKSON MILLS AND MINE FALLS DAMS NASHUA, N.H. | | | |
| RECONNAISSANCE REPORT HYDROELECTRIC FEASIBILITY MINE FALLS DAM SITE | | | |
| | | | SCALE: 1" = 20' |
| | | | DATE: DEC, 1979 |



PLAN



PROFILE



| | | |
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| Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE | | U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA. |
| JACKSON MILLS AND MINE FALLS DAMS NASHUA, N.H. | | |
| RECONNAISSANCE REPORT HYDROELECTRIC FEASIBILITY MINE FALLS CANAL SITE | | |
| | | SCALE: 1" = 20' |
| | | DATE: MAY, 1979 |

DEFINITIONS AND TERMS

CAPACITY - The maximum power output or load for which a turbine-generator, station or system is rated.

DEPENDABLE CAPACITY - The load carrying ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified of a particular system load.

DRAWDOWN - The distance that the water surface elevation of a storage reservoir is lowered from a given or starting elevation as a result of the withdrawal of water to meet some project purpose (i.e., power generation, creating flood control space, irrigation demand, etc.).

ENERGY - The capacity for performing work. The electrical energy term generally used is kilowatt-hours and represents power (kilowatts) operating for some time period (hours).

FEDERAL ENERGY REGULATORY COMMISSION (FERC) - An agency in the Department of Energy which licenses non-Federal hydropower projects and regulates interstate transfer of electric energy. Formerly the Federal Power Commission (FPC).

FIRM ENERGY - The energy generation ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified of a particular system load.

FOREBAY - The impoundment immediately above a dam or hydroelectric plant intake structure. The term is applicable to all types of hydroelectric developments (i.e., storage, run-of-river and pumped-storage).

GENERATOR - A machine which converts mechanical energy into electric energy.

GROSS HEAD - The difference in water surface elevation as measured in the forebay and tailrace of a hydropower plant, under certain specified conditions. Usually, gross head refers to the difference between normal full pool and average tailwater elevations.

HYDROELECTRIC PLANT or HYDROPOWER PLANT - An electric power plant in which the turbine/generators are driven by falling water.

INSTALLED CAPACITY - The total of the capacities shown on the nameplates of the generating units in a hydropower plant.

KILOWATT (Kw) - One thousand watts.

KILOWATT-HOUR (Kwh) - The amount of electrical energy involved with a one-kilowatt demand over a period of one hour. It is equivalent to 3,413 Btu of heat energy.

LICENSE APPLICATION - The FERC issues two types of licenses: one for projects of less than 1.5 Mw in capacity (minor project) and one for large projects (major project).

LOAD - The amount of power needed to be delivered at a given point on an electric system.

MEGAWATT (Mw) - One thousand kilowatts.

MEGAWATT-HOURS - (Mwh) - One thousand kilowatt-hours.

NET HEAD - Also called effective head. The gross head less all hydraulic losses except those chargeable to the turbine.

PENSTOCK - A conduit used to convey water under pressure, to the turbines of a hydroelectric plant.

PLANT FACTOR - Ratio of the average load to the plants installed capacity, expressed as an annual percentage.

PONDAGE - The amount of water stored behind a hydroelectric dam of relatively small storage capacity used for daily or weekly regulation of the flow of a river.

POWER (ELECTRIC) - The rate of generation or use of electric energy, usually measured in kilowatts.

PUBLIC UTILITIES COMMISSION - In New Hampshire the state agency which oversees that adequate utility service is provided at fair and reasonable rates. The commission is an arm of the State Legislature and has the power to establish utility rates, audit utilities through financial reports, establish service territories for utilities and set standards of service for utilities.

RIPARIAN LAW - In New Hampshire where the developer's land borders upon a stream, his ownership will include the bed of the stream. The ownership of the land bordering the stream gives the developer ownership of the right to use the water, not ownership of the water. This may be contrasted to the Western Riparian law under which the right to use flowing water accrues in the first user rather than the Riparian or bordering owner.

RUN-OF-RIVER PLANT - A hydroelectric generating plant which depends chiefly on the flow of a stream or river as it occurs for generation purposes, as opposed to a storage project, which has sufficient storage capacity to carry water from one season to another. Some run-of-river projects have a limited storage capacity (pondage) which permits them to regulate streamflow on a daily or weekly basis.

SPECIAL BOARD - In New Hampshire Water Resources Board a committee which issues permits pertaining to dredging a watercourse for the purpose of increasing the depth of the impoundment area or filling to insure structural stability before construction. The Special Board includes members of the Water Resources Board, Fish and Game, and the Water Supply and Pollution Control Commission.

SPINNING RESERVE - Generating units operating at no load or at partial load with excess capacity readily available to support additional load.

STANDBY RESERVE - Generating equipment or other facilities reserved for use in case of outages or other emergency operating conditions. The generating equipment and other facilities may or may not be in service normally. This category of reserve should not be confused with spinning reserve.

SYNCHRONIZED OPERATION - An operation wherein electrical generating facilities are electrically connected and controlled to operate at the same frequency. It is synonymous with operation in parallel.

TAILWATER - The water surface elevation immediately downstream from a dam or hydroelectric power plant. A high tailwater condition reduces the hydraulic head and thus the efficiency of a hydroelectric generating station.

TRANSMISSION - The act or process of transporting electric energy in bulk.

TRANSMISSION GRID - An interconnected system of electric transmission lines and associated equipment for the movement or transfer of electric energy in bulk between points of supply and points of demand.

TURBINE - The part of a generating unit which is spun by the force of water or steam to drive an electric generator. The turbine usually consists of a series of curved vanes or blades on a central spindle.

WATER RESOURCE BOARD - In New Hampshire a state board established to oversee the conservation of water, the control of discharges from dams and all public water related projects. The Water Resources Board is also concerned with the registration of dams and will determine if the dam is a menace to public safety.

WHEELING - Transportation of electricity by a utility over its lines for another utility; also includes the receipt from and delivery to another system of like amounts but not necessarily the same energy.

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13. Board of Aldermen of the City of Nashua, Resolution R-78-104, 1978.
14. Hillsborough County Registry of Deeds, Conservation Easement. Book 2290, pp. 295-296, 13 April 1973.